To: North East Texas Regional Water Planning Group

From: Dawn Pilcher, P.E., LJA Engineering, and David Dunn, P.E., HRD Engineers, on behalf of Riverbend Water Resources District

Date: January 29, 2019

Re: Sediment Accumulation in Wright Patman Lake

I. Introduction

Since adoption of the 2016 Northeast Texas (Region D) Regional Water Plan and 2017 State Water Plan, parties have expressed concern regarding the amount of storage in Wright Patman Lake that has apparently been lost to sedimentation. Of particular concern is how that lost storage capacity will affect regional water supplies and how to appropriately mitigate the apparent sedimentation problem. This memorandum is intended to address the following issues:

1. Clarify the nature of the sedimentation and water supply problem (if any) at Wright Patman Lake;
2. Provide an appropriate perspective regarding the effects of sedimentation on supplies available from Wright Patman Lake; and
3. Respectfully, request the inclusion of scenarios offering how supplies from Wright Patman Lake should be reflected in the regional and state water planning process.

II. Background

Wright Patman Lake was constructed by the U.S. Army Corps of Engineers (USACE) as primarily a flood control project, pursuant to the stated authorization of the USACE.[1] However, the USACE is authorized to contract for a portion of the storage capacity to be utilized for water supply purposes for participating local entities, or sponsors. In the case of Wright Patman Lake, the local sponsors under contract with the USACE are the Cities of Texarkana, Texas and Arkansas, with the City of Texarkana, Texas holding all currently adjudicated state water rights from Wright Patman Lake. The water supply storage capacity in the lake is typically referred to as "conservation storage."

The conservation storage volume in Wright Patman Lake is defined according to a seasonal "rule curve," where the reservoir is to be kept as closely as possible to target elevations that vary throughout the year.

One contract for water supply storage exists between the USACE and the Cities of Texarkana, Texas and Texarkana, Arkansas, and two additional contracts[2] exist between the USACE and the City of Texarkana,

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[1] Wright Patman Lake was authorized by Public Law 79-526 in accordance with the Chief's Report for the Red River Project published under House Document 602, 79th Congress, 2nd Session and referenced by the Flood Control Act of July 1946.

[2] In May 1953, the Secretary, and the cities of Texarkana, TX and Texarkana, AR (Cities) executed a Surplus Water Agreement (Contract No. DA-16-047-eng-2033) under the authority of Section 6 of the Flood Control Act of 1944 to make available a dependable supply of water without appreciably affecting the usefulness for other planned purposes of Wright Patman Lake. The "original" agreement provided the Cities the ability to withdraw water from

Texas for Wright Patman Lake. The latter two contracts expanded upon the initial water supply storage pool within Wright Patman Lake with the definition of: 1) the "Operating Rule Curve" (or "Ultimate Rule Curve") through the "End of State" Contract[3] or Permanent Contract and 2) the "Operating Rule Curve, Interim Water Supply" (or "Interim Rule Curve") through the Interim Contract.[4] In April 1968, the Secretary and the City of Texarkana, Texas executed an agreement to provide permanent rights to water supply storage at Wright Patman Lake. The authority to convert flood control storage to water supply storage is based on the same authority for Cooper Lake (now Jim Chapman Lake), which provides the ability to permanently reallocate flood control space above 220.0 ft msl to water supply storage at Wright Patman Lake. This permanent conversion of flood control storage to water supply storage is in addition to the 13 million gallons per day (mgd) made available under the Original Contract. The contract is expected to provide an unspecified amount of dependable yield for the City of Texarkana, Texas and surrounding entities over and above the 13 mgd dependable yield for the Cities (Texarkana, AR and Texarkana, TX), plus 6.5 mgd for Government use in maintaining downstream minimum flow in the Sulphur River. The water supply was to come from storage provided via a defined operating rule curve (Ultimate Rule Curve) and minimum pool elevation above 220.0 feet msl.[5] The operating rule curve varies by month from a minimum top of conservation pool elevation of 224.89 to a maximum top of conservation pool elevation of 228.64 feet (see Figure 1).

Wright Patman Lake when the reservoir was above elevation 220.0 ft msl. The agreement became effective upon approval of the agreement by the Secretary (February 16, 1954), and is to remain in effect for the useful life of the project.

[3] In April 1968, the Secretary, and the City of Texarkana, TX executed a Surplus Water Agreement (Contract No. DACW29-68-A-0103) to make available additional dependable water supply from Wright Patman Lake, which after the construction of Cooper Reservoir, could be stored in Wright Patman Lake without appreciably affecting the usefulness for other planned purposes of the project. The Ultimate Rule Curve is defined in Appendix A of this contract.

[4] To facilitate use of water by the City of Texarkana prior to construction or Cooper Dam and full implementation of the Permanent Contract, the City and Government entered into an Interim Contract (Contract No. DACW29-C-0019) dated September 14, 1968 to provide the City the right to store and withdraw water from the storage space between the interim operating rule curve and elevation 220.0 ft msl. The storage space defined by the Interim Rule Curve represents a determination that the space is surplus to authorized operations for flood control. The Interim Rule Curve provides 84.0 mgd of dependable yield in addition to the 13 mgd dependable yield expected to be derived from the storage space defined in the Original Contract, plus 6.5 mgd for the maintenance of minimum flow. The Interim Contract became effective as of the date of approval by the Secretary (December 17, 1968), and will be terminated when the Permanent Contract becomes effective.

[5] Both the Interim Contract and Permanent Contract contain provisions that allow the City of Texarkana to make withdrawals which lower the water level below elevation 220.0: Under the Interim Contract, the Government shall provide "appropriate contingency provisions for the use of space below the normal operating pool elevation of 220 feet above mean sea level, when necessitated by unusually low runoff over a protracted period." Under the Permanent Contract this may occur, so long as "expressly approved in writing by the Contracting Officer."

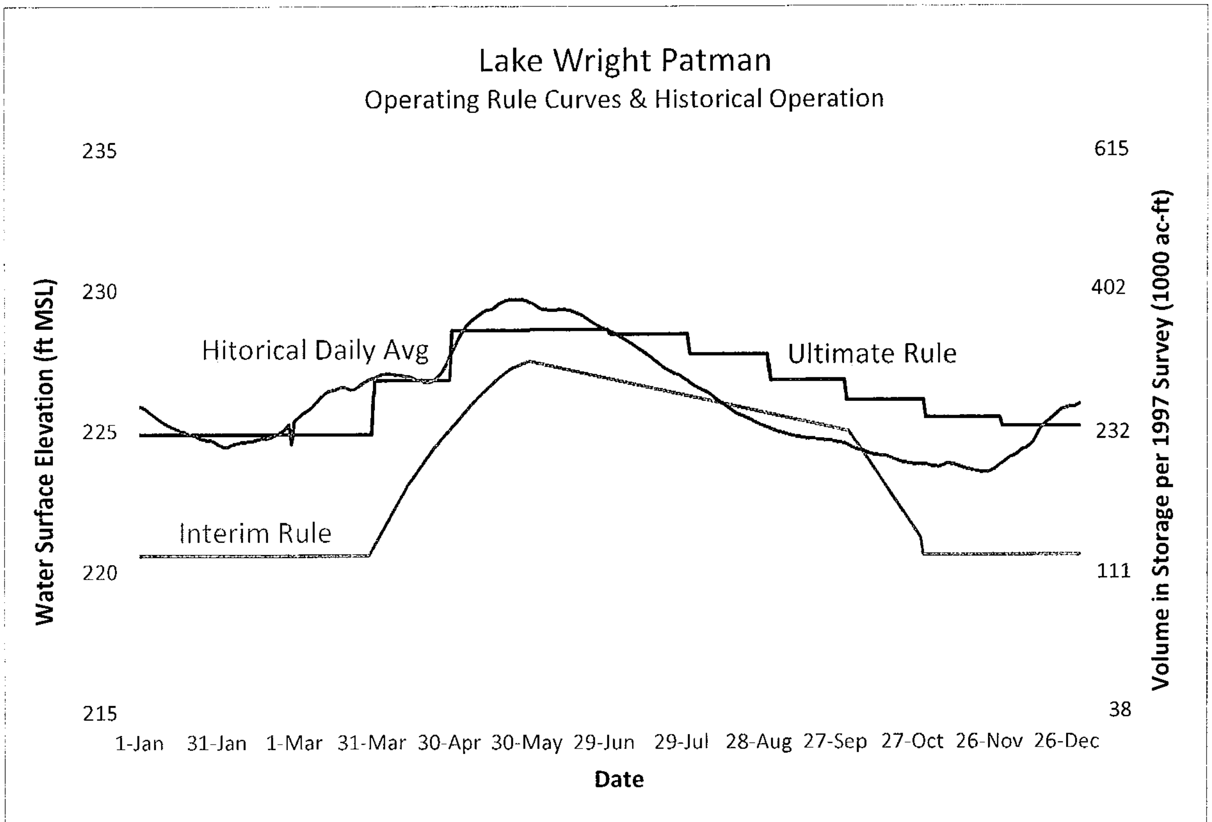

Figure 1. Wright Patman Lake Operating Rule Curves

The dark blue line in Figure 1 represents the Ultimate Rule Curve with a minimum top of conservation of 224.89 feet msl from January through March which rises to 228.61 feet msl in June and 228.64 in July. The Ultimate Rule Curve provides for a minimum of 120,000 acre-feet of water supply storage in the winter to a maximum of 241,600 acre-feet of summer time conservation supply above elevation 220.0 feet msl for permanent water supply storage. The effective date for water withdrawal from Wright Patman Lake is the later of 1) the date of the deliberate impoundment of Cooper Lake (now Jim Chapman Lake), or 2) the date of completion of all modifications to Wright Patman Lake are required to effect the conversion of flood control storage to water supply storage and provides permanent rights to storage for water supply use.

The Permanent Contract is not currently in effect as all modifications required to effect the conversion of flood control storage at Wright Patman Lake have not been complete; however, **the Ultimate Rule Curve is the appropriate operating scenario when determining the firm yield of Wright Patman Lake for planning purposes**, because the Ultimate Rule Curve is specified in the water right (Certificate of Adjudication CA 03-4836) authorizing impoundment and use of water from the lake by the Texas Commission on Environmental Quality (TCEQ). Although the Texas Water Development Board (TWDB) planning guidelines would allow the Region D Planning Group to constrain the water supplies available from Wright Patman Lake to the Interim Rule Curve, it is the preference of Riverbend to utilize the Ultimate Rule Curve as the basis of its local supply and thereby maintain consistency with the established water rights issued from the lake and the current TCEQ Water Availability Model for the Sulphur River Basin. While the Ultimate Rule Curve has not been officially implemented, the U.S. Army Corps of

Engineers normally operates this project to closely mimic the Ultimate Rule Curve rather than the Interim Curve as evidenced in the green line in Figure 1, above. Finally, Riverbend is currently working with the USACE to begin studies that will facilitate official implementation of the Ultimate Rule Curve. If Region D continues to limit the yield of Wright Patman Lake by utilizing the Interim Rule Curve, then Riverbend requests that the Region D Planning Group clearly identify implementing the Ultimate Rule Curve as a strategy for increasing available supply in the region.

Although the Ultimate Rule Curve should be used for planning purposes, sedimentation and bathymetric survey analyses by the TWDB previously focused on the Interim Rule Curve, as described below.

III. DETERMINATION OF WRIGHT PATMAN LAKE STORAGE CAPACITY AND SEDIMENTATION

Various estimates of the storage available in Wright Patman Lake have been developed including the following: A) the initial estimates by the USACE when the reservoir was constructed in 1956; B) Texas Water Development Board (TWDB) reservoir volumetric survey performed in 1997 and volumetric and sedimentation survey performed in 2010; and C) a reservoir sediment and bathymetric survey commissioned by Riverbend Water Resources District in 2018. For water planning purposes, **Riverbend recommends that Region D Planning utilize the most recent 2018 bathymetric study elevation-area-capacity relation in establishing the "Current Conditions" for Wright Patman Lake.**

A. Initial Storage Capacity (USACE, 1956)

As part of the original design documentation, the USACE determined the volume of available storage capacity in Wright Patman Lake in 1956 to be 158,000 ac-ft below elevation 220.6' MSL and 265,343 ac-ft below elevation 224.90' MSL. The elevation of 220.6' corresponds to the lowest top of conservation pool level under the Interim Rule Curve while elevation 224.90' represents the lowest seasonal level under the Ultimate Rule Curve. The USACE further projected that in 50 years an estimated 68,000 ac-ft of sediment would be deposited and displace the initial water storage capacity. This prediction by USACE estimated or anticipated an average annual sedimentation rate of 1,360 ac-ft/year, or 0.40 ac-ft of sediment per square mile of contributing watershed.

B. TWDB Sediment and Bathymetric Surveys (1997 and 2010)

The TWDB performed bathymetric surveys of Wright Patman Lake in 1997 and 2010 and also performed a sediment survey in 2010. While the bathymetric surveys determined updated storage capacities of the reservoir in 1997 and 2010, the sediment survey in 2010 provided a more direct estimate of the amount of sediment deposited since impoundment. The sediment survey is based upon sediment cores and sub-bottom profiling depth sounder data. Using improved computational methods, the data obtained during the 1997 bathymetric survey were re-analyzed to determine an updated estimate of the 1997 capacity.

In 2010, TWDB determined capacities within Wright Patman Lake at various points in time and at various elevations. The following table includes key points from the TWDB reports:

Table 1. Summary of TWDB Bathymetric and Sediment Surveys (1997 and 2010) (all capacities shown in ac-ft)

Elevation	Initial (1956) USACE Capacity	Pre-Impoundment Capacity (per sediment survey)	1997 Capacity	2010 Capacity
220.6 (Interim Curve Low Pt)	158,000	137,336	115,638	97,927
224.9 (Ultimate Curve Low Pt)	265,300	238,453	209,439	192,931

C. <u>2018 Sediment and Bathymetric Survey (Riverbend Commissioned Study Jointly Funded by SRBA)</u>

In July 2018, Arroyo Environmental Consultants, LLC (Arroyo) along with partner firm Aqua Strategies Inc., performed volumetric (bathymetric) and sedimentation surveys of Wright Patman Lake for Riverbend Water Resources District (Riverbend) jointly funded by the Sulphur River Basin Authority (SRBA). Based on this most recent sedimentation survey, Arroyo estimated that the original pre-impoundment capacity of Wright Patman Lake was 126,729 ac-ft, at elevation 220.6 feet.

Table 2 presents a comparison of lake volumes and sediment rates for Wright Patman Lake, based upon the 1997, 2010, and 2018 bathymetric and sediment surveys for elevation 220.6' MSL. Table 3a presents a subset of the data in Table 2 to focus on results obtained from the 2018 survey. Table 3b provides the same series of information as Table 3a but extends the data to represent elevation 224.9' MSL in Wright Patman Lake. As evidenced in Tables 2, 3a, and 3b, the apparent sedimentation rate varies widely depending on the period of record observed and the presumed initial volume of the reservoir from the start of intentional impoundment in 1956. The averages of the available analysis periods are 653 ac-ft/year below elevation 220.6' and 682 ac-ft/year below elevation 224.9'.

For Region D surface water planning purposes, Riverbend recommends that the 2018 bathymetric survey of Wright Patman Lake be utilized, extrapolated to cover the full range of the Ultimate Rule Curve, to define current reservoir conditions. Furthermore, Riverbend recommends use of 680 ac-ft/year as the annual sedimentation rate in Wright Patman Lake, below elevation 224.9' MSL, for forecasting future impacts to the water supply and firm yield from Wright Patman Lake.

Reservoir Capacity Determination	Reservoir Capacity at 220.6 feet (NGVD29)												
	Relative to Original USACE Design Estimate				Relative to 2010 Sediment Survey Pre-Impoundment Determination			Relative to 2018 Sediment Survey Pre-Impoundment Determination			Comparisons between Various Bathymetric Surveys		
	USACE (1956)	1956 to 1997	1956 to 2010	1956 to 2018	1956 to 1997	1956 to 2010	1956 to 2018	1956 to 1997	1956 to 2010	1956 to 2018	1997 to 2010	1997 to 2018	2010 to 2018
Original USACE Design Estimate	158,000	158,000	158,000	158,000									
Pre-Impoundment (2010 Survey)					137,336	137,366	137,366						
Pre-Impoundment (2018 Survey)								126,729	126,729	126,729			
1997 Volumetric Survey (ac-ft) as recalculated in 2010		115,638			115,638			115,638			115,638	115,638	
2010 Volumetric Survey (ac-ft)			97,927			97,927			97,927		97,927		97,927
2018 Volumetric Survey (ac-ft)				96,430			96,430			96,430		96,430	96,430
Sediment Accumulated (ac-ft)	68,000*	42,362	60,073	61,570	21,698	39,439	40,936	11,091	28,802	30,299	17,711	19,208	1,497
Number of Years	50	41	54	62	41	54	62	41	54	62	13	21	8
Annual Capacity Loss (ac-ft/yr)	1,360	1,033	1,112	993	529	730	660	271	533	489	1,362	915	187
Annual Capacity Loss per Sq. Mi. of Watershed (ac-ft/yr)	0.400	0.304	0.327	0.292	0.156	0.215	0.194	0.080	0.157	0.144	0.401	0.269	0.055

range: 993-1033 ac-ft/year; avg= 1,046 range: 529-730/year; avg= 640 range: 271-533 ac-ft/year; avg= 431 range: 187-1362 ac-ft/year; avg= 821

Table 2. Comparison of Lake Volumes and Sediment Rates to Elevation 220.6' MSL, Computed for Wright Patman Lake

Reservoir Capacity Determination	Reservoir Capacity at 220.6 feet (NGVD29)				
	1956 (USACE) to 2018 (Arroyo)	1956 (per 2010 Sed Survey) to 2018 (Arroyo)	1956 (per 2018 Sed Survey) to 2018 (Arroyo)	1997 (TWDB) to 2018 (Arroyo)	2010 (TWDB) to 2018 (Arroyo)
Original USACE Design Estimate	158,000				
Pre-Impoundment (2010 Survey)		137,366			
Pre-Impoundment (2018 Survey)			126,729		
1997 Volumetric Survey (ac-ft) as recalculated in 2010				115,638	
2010 Volumetric Survey (ac-ft)					97,927
2018 Volumetric Survey (ac-ft)	96,430	96,430	96,430	96,430	96,430
Sediment Accumulated (ac-ft)	61,570	40,936	30,299	19,208	1,497
Number of Years	62	62	62	21	8
Annual Capacity Loss (ac-ft/yr)	993	660	489	915	187
Annual Capacity Loss per Sq. Mi. of Watershed (ac-ft/yr)	0.292	0.194	0.144	0.269	0.055

range: 187-993/year; avg= 649

Table 3a. Comparison of Prior Lake (below elevation 220.6') Volume Estimates to 2018 Survey Results

Reservoir Capacity Determination	Reservoir Capacity at 224.9 feet (NGVD29)				
	1956 (USACE) to 2018 (Arroyo)	1956 (per 2010 Sed Survey) to 2018 (Arroyo)	1956 (per 2018 Sed Survey) to 2018 (Arroyo)	1997 (TWDB) to 2018 (Arroyo)	2010 (TWDB) to 2018 (Arroyo)
Original USACE Design Estimate	265,300				
Pre-Impoundment (2010 Survey)		238,453			
Pre-Impoundment (2018 Survey)			225,000		
1997 Volumetric Survey (ac-ft) as recalculated in 2010				209,439	
2010 Volumetric Survey (ac-ft)					192,931
2018 Volumetric Survey (ac-ft)	191,156	191,156	191,156	191,156	191,156
Sediment Accumulated (ac-ft)	74,144	47,297	33,844	18,283	1,775
Number of Years	62	62	62	21	8
Annual Capacity Loss (ac-ft/yr)	1,196	763	546	871	222
Annual Capacity Loss per Sq. Mi. of Watershed (ac-ft/yr)	0.352	0.224	0.161	0.256	0.065

range: 222-1,196/year; avg= 719

Table 3b. Comparison of Prior Lake (below elevation 224.9') Volume Estimates to 2018 Survey Results

IV. SEDIMENTATION ANALYSIS IN WRIGHT PATMAN LAKE

A. Analysis of Bathymetric and Sedimentation Surveys in Wright Patman Lake

With several data sets to evaluate, the history of sedimentation in Wright Patman Lake can be summarized as follows:

Since intentional impoundment began in 1956, the project has experienced sedimentation at a rate that is much lower than the original expectations of the USACE designers, and therefore, the sediment accumulation experienced in the reservoir is not alarming or offensive.

The original 1956 USACE design data allowed for a sediment reserve of 68,000 ac-ft. This volumetric reservation is noted without regard for elevation. Since the typical design life expectancy of USACE reservoirs is 50 years, and with due consideration for the size, terrain, and soils of the contributing drainage basin, the USACE expected Wright Patman Lake to receive approximately 68,000 ac-ft of sediment over a 50-year period. The USACE predicted sedimentation rate equates to 0.40 ac-ft of average annual sediment deposit in Wright Patman Lake for each square mile of its contributing watershed.

While the USACE estimate for sediment deposition in Wright Patman Lake is not constrained to a specific elevation, the analysis of data collected by TWDB in 2010 and by Arroyo Environmental in 2018 is focused on the water supply conservation pool within Wright Patman Lake and therefore limited to the area below 224.9′ MSL. The 2010 TWDB volumetric and sedimentation survey provided a direct physical assessment and the current capacity of the lake in the lower pool levels along with a surveyed "pre-impoundment" condition which supports a long-term average annual sedimentation rate of 0.25 ac-ft per square mile of contributing drainage basin. In 2018, Arroyo Environmental performed another volumetric and sedimentation survey on Wright Patman Lake which yielded results that indicated a long-term sedimentation rate of 0.16 ac-ft/year per square mile of contributing watershed based on their current volumetric capacity and corresponding "pre-impoundment" condition as determined by their sedimentation survey.

Although each survey yields different results, it is clear that the Wright Patman Lake is not experiencing excessive or unanticipated sediment loading or loss of water storage capacity. The displacement of water storage space with sediment accumulation is occurring at a reasonable rate which is one of the lowest sedimentation rates for the region's lakes (see column labeled "annual sediment/ sq-mi drainage basin" in Table 4 of this report).

Another observation offered here makes the case for continued monitoring and data collection. For instance, during the 13-year period between the 1997 and 2010 studies, sediment accumulation increased slightly. Yet, during the next 8-year period between the 2010 and 2018 studies, sediment accumulation decreased. This can be most likely attributed to varying rainfall events throughout the basin. For example, the period of 1997 to 2010 experienced more frequent flood events which may have transported more sediment into the lake, while less frequent high runoff events during the 2010 to 2018 time span could have resulted in a period of lower sedimentation in the lake.

Overall, reservoir sedimentation is expressed as average annual accumulation rates, determined from relatively infrequent bathymetric and/or sediment surveys. Actual sedimentation rates vary considerably from year to year and depend upon watershed processes and extreme hydrologic events. A standard rule of thumb estimates that as much as 90 percent of a river's sediment load is carried by less than 10 percent of its flows. In other words, low and moderate flow levels contribute only small amounts of sediment into a reservoir – reservoir sedimentation is caused by high-flow events having the hydraulic capacity to mobilize large quantities of sediment. As previously provided, Table 2 presents several alternative sedimentation rates for Wright Patman Lake. These combined data demonstrates the variability of reservoir sedimentation rates.

B. Wright Patman Lake Sedimentation for Future Planning

Although the original methods by which the reservoir designers determined the initial elevation-capacity relationships for the lake are unclear, the data collection, processing, and modeling methodology employed by the TWDB hydrographic survey staff and Arroyo are supported by sound scientific and mathematical principles and practices, and the results of those surveys are not disputed by this report.

The 2018 bathymetric survey is the most up-to-date and recent information available regarding the current capacity of Wright Patman Lake. Due to water surface elevations in Wright Patman Lake at the time of Arroyo's bathymetric survey, data collection was limited to a maximum elevation of 224.0'. In order to utilize the results of this survey to represent current conditions for water planning, the data set can be extrapolated to the top of the Ultimate Rule Curve (elevation 228.64') with relative ease. **Riverbend recommends that the elevation-area-capacity tables presented in the report for the 2018 bathymetric survey be applied as "current conditions" for the Wright Patman Lake in the 2021 Region D Water Plan. As previously stated, Riverbend further recommends application of an annual sedimentation rate of 680 ac-ft into Wright Patman Lake below elevation 224.9' for modelling and projecting future water supplies from the project.** This sediment rate provides a balance between the most realistic picture of what is happening in Wright Patman Lake today with respect to sediment accumulation and what should be planned for in the future.

As noted previously, the Arroyo 2018 bathymetric survey data collection was limited to a maximum elevation of 224.0'. Prior surveys were faced with similar limitations. The 1997 TWDB survey data collection was limited to elevation 225.7' and the 2010 survey data set was limited to 224.5' MSL. **Riverbend recommends that future bathymetric and sedimentation surveys are performed on a 10-year cycle and targeted for periods when the water surface in the lake is at an elevation of 230.0' or higher and that lake operation is coordinated with USACE Reservoir Operations to attempt to hold the lake at this slightly elevated position for the duration of the survey.**

C. Wright Patman Lake Comparison to Other Area Reservoirs

The 2016 Region D Plan presents the capacities of reservoirs in Region D based upon initial estimates and recent volumetric surveys, as shown below (Table 1.7, page 1-33).

Table 4. Capacity of Reservoirs with Recent Volumetric Surveys (2016 Region D Plan, Table 1.7, page 1-33)

Reservoir	Previously Reported Capacity at Conservation Pool – (ac-ft)	Date of Previous Report	Recent Capacity at Conservation Pool – (ac-ft)	Study Date	Percent Reduction
Lake Bob Sandlin	213,350	1975	201,733	2008	5.4
Lake Cherokee	49,295	1948	43,737	2003	11.3
Lake Cypress Springs	72,800	1971	66,756	2007	8.3
Lake Monticello	40,100	1973	34,740	1998	13.4
Lake O' The Pines	254,900	1958	241,363	2009	5.3
Lake Tawakoni	936,200	1960	871,693	2009	6.9
Wright Patman Lake	158,000	1956	97,927	2010	38
Lake Gladewater	6,950	1952	4,738	2000	31.8
Lake Fork	675,819	1980	636,504	2009	5.8
Welsh Reservoir	23,587	1975	20,242	2001	14.2
Lake Crook	11,487	1923	9,210	2009	19.8
Pat Mayse Lake	124,500	1967	117,844	2009	5.3

This table presents a very large (38 percent) reduction in the capacity of Wright Patman Lake, between the time of impoundment and the 2010 TWDB bathymetric survey. Because of this presentation, concerns have been expressed in the region that this indicates a serious problem with sedimentation in Wright Patman Lake. **While the actual data are not in dispute, presenting sedimentation accumulation as a percent of conservation storage can distort overall understanding regarding the nature of the problem.** While a physical reduction in storage capacity is partially due to sedimentation, there are several other contributors to the apparent reductions to capacity beyond the volume displaced by sediment accumulation.

First, there is a significant variance between the original USACE estimation of initial capacity and the "pre-impoundment" condition determined by the TWDB 2010 sedimentation survey and that difference in volume is attributable to initial conditions, not sediment accumulation. Based upon the 2010 TWDB sediment and bathymetric surveys, the pre-impoundment capacity of Wright Patman Lake was 137,336 ac-ft, or 20,664 ac-ft less than the 158,000 ac-ft USACE pre-impoundment estimate.

Second, in simply presenting the total historic sediment accumulation in each lake relative to original design data, without consideration for years of operation or contributing drainage basin, the Region D Plan Table 1.7 provides an incomplete comparison between lakes and an alarming value for Wright Patman Lake. Table 5 of this memorandum, provides a more complete alternate to the Region D Plan Table 1.7. Furthermore, the 38% volumetric reduction calculation for Wright Patman Lake is further skewed by the "top of conservation" pool elevation selected for analysis. As mentioned previously, the analytical review of data undertaken for this memorandum considered both elevations 220.6′ and 224.9′ for conservation pool assessment. When evaluating the same data set presented in Table 1.7 and extending the analysis to provide truly comparable values, and including Wright Patman Lake to elevation 224.9′, the following table results:

Table 5. Alternative Presentation of Sedimentation Results for Table 1.7.

Reservoir Name	Previous Report/ Orig Design Data		Recent Bathymetric Survey Report		Ac-Ft Reduction		Drainage Basin	annual sediment/ sq-mi drainage basin	storage/ sq-mi drainage basin (ac-ft/sq-mi)
	Capacity (ac-ft)	Date	Capacity (ac-ft)	Date	total	annual	Area (sq-mi)		
Lake Bob Sandlin	213,350	1975	201,733	2008	11,628	352	239	1.474	844.1
Lake Cherokee	49,295	1948	43,737	2003	5,558	101	158	0.640	276.8
Lake Cypress Springs	72,800	1971	66,756	2007	6,044	168	75	2.239	890.1
Lake Monticello	40,100	1973	34,740	1998	5,360	214	36	5.956	965.0
Lake O' the Pines	254,900	1958	241,363	2009	13,537	265	850	0.312	284.0
Lake Tawakoni	936,200	1960	871,693	2009	64,507	1,316	756	1.741	1153.0
Wright Patman Lake (to elev. 220.6')	137,366*	1956	96,338	2018	41,028	662	3400	0.195	28.3
Wright Patman Lake (to elev. 224.9')	238,453*	1956	192,000	2018	46,453	749	3400	0.220	56.5
Lake Gladewater	6,950	1952	4,738	2000	2,212	46	35	1.317	135.4
Lake Fork	675,819	1980	636,504	2009	39,315	1,356	493	2.750	1291.1
Welsh Reservoir	23,587	1975	20,242	2001	3,345	129	21.2	6.069	954.8
Lake Crook	11,487	1923	9,210	2009	2,277	26	52	0.509	177.1
Pat Mayse Lake	124,500	1967	117,844	2009	6,656	158	175	0.906	673.4

* Original Capacity for Wright Patman Lake as determined for "pre-impoundment" conditions by TWDB sedimentation survey performed in 2010.

As evidenced in the above table, sediment contribution is highly variable from one basin to the next; however, when comparing annual sedimentation rates between reservoirs with consideration for contributing drainage areas, the resulting annual sediment accumulated in Wright Patman Lake per square mile of drainage area is one of the lowest across the region. In fact, the sediment rates as shown in **Table 5** are consistent and actually smaller, than other reservoirs in the region. **Therefore, Wright Patman Lake does not have a sedimentation problem any worse than any of the other area reservoirs. Any volumetric loss in Wright Patman Lake that has been presented in other recent basin-wide studies does not correlate directly with reduced capacity resulting from sedimentation and certainly is not fully attributable to sediment accumulation.**

While the measures of volumetric capacity and reliable or firm annual yield can be confusing due to both values typically being presented in terms of acre-feet, the distinction between the two parameters is critically important. Volumetric capacity is simply a measure of how much water a lake can contain behind the dam, up to a certain elevation. Reliable annual yield is a measure of how much water can be withdrawn from a lake, from below that same certain elevation, in any given year, including through periods of droughts, without causing the lake to run dry. Volumetric capacity is a fairly straightforward measurement of the physical condition of a lake. Reliable water supply, or firm yield, is a more complicated matter which takes into consideration a multitude of factors such as desired water withdrawal schedules, rainfall patterns, evaporation, environmental considerations, and priority of other water right holders within the basin. To further complicate matters, "water availability" which is typically reported in the same ac-ft per year units as firm yield, and sometimes referred to interchangeably, is generally assessed with consideration for access and infrastructure limitations.

For Region D planning purposes, Riverbend recommends that an alternative, extended version of the Region D 2016 Planning Report Table 1.7 be utilized as provided above in Table 5. Furthermore, the impact of the sediment accumulation on supplies is what should be emphasized, rather than a simplistic comparison of loss of current volume storage.

V. WATER SUPPLIES FROM WRIGHT PATMAN LAKE

The regional water planning process utilizes several different definitions of supply, depending on what is trying to be conveyed. For reservoirs, the concept of firm yield is used, which is the annual amount of water that may be withdrawn from a reservoir during a repeat of the drought of record with the reservoir just going dry. This firm yield is computed for each decade of the regional water plan, and typically reduces each decade due to accumulating sediment reducing available storage. The firm yield of a reservoir may be greater or less than the diversions authorized by the reservoir's underlying water right. Therefore, the regional planning process assumes that the annual supply from a reservoir in each planning decade is limited to the lesser of the firm yield or the annual diversions authorized in the reservoir's water right.

Beyond the firm yield analysis for a reservoir, which is exclusive of the existence of infrastructure needed to extract and utilize the water supply, the regional planning process evaluates available water supply which may be constrained or further limited by existing infrastructure. Following a firm yield determination, or water supply available from the lake, existing infrastructure is evaluated for the ability to capture and put the water supply to beneficial use. This assessment of available water supply generally includes evaluations of diversion, transmission or treatment facilities.

Some previous analyses of the firm yield of Wright Patman Lake have incorrectly assumed that a contractual provision with the USACE prevents diversions occurring when the reservoir falls below elevation 220.0' MSL. A proper reading of the contractual terms indicates that diversions can be made below the 220.0' elevation with written permission of the USACE. Therefore, unnecessarily limiting the lowest practical elevation to 220.0 feet places an undue and inappropriate constraint on the water supply from Wright Patman Lake. **As with following the Ultimate Rule Curve to define the top of the conservation pool to maintain consistency with current water rights modeling by TCEQ, Riverbend recommends firm yield analysis to determine supplies from Wright Patman Lake should allow the full conservation capacity to be utilized and not be limited to storage above 220.0 feet elevation.**

Region D has prepared draft yield results from Wright Patman Lake as shown in Table 6.

Table 6. Draft Firm Yield Projected for Wright Patman Lake for Use in the 2021 Region D Plan

	Projected Firm Yield of Wright Patman Lake (ac-ft/year)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
Region D 2021 Plan Results (DRAFT dated 8 Aug, 2018)	---	327,300	302,260	279,990	253,940	231,120	208,500

The above firm yield projections utilize a reservoir sedimentation rate of 1,000 ac-ft/yr, which is much greater than has been experienced since construction of the reservoir. This same table then reports firm yield results relative to a WAM evaluation utilizing the ultimate rule curve and a lake geometry representative of the 2010 TWDB bathymetric survey along with imposed limitations from misinterpreted contractual language regarding normal low pool constraints. Continued sediment accumulation and the improperly applied contractual limitations are then carried forward in the forecasted firm yield of Sulphur Basin water sources as presented in the 2016 Region D report in Table 3.5 Sulphur River Basin Surface Firm Yield (ac-ft/yr). **The draft 2021 Region D Plan firm yield supplies projected from Wright Patman Lake should be recomputed using a sedimentation rate of 680 ac-ft/yr and without application of limits with regard to an imposed minimum pool requirement.**

As noted earlier, the water right for Wright Patman Lake (CA 03-4836) authorizes an annual diversion of 180,000 ac-ft/year from the reservoir. All of the firm yields projected for the reservoir exceed the currently authorized diversions from the reservoir. **Region D should recommend a water management strategy for Riverbend to pursue measures necessary to make the full firm yield from Wright Patman Lake available for beneficial use.**

Further, current supplies from Wright Patman Lake are constrained by the elevation of the existing intake. Diversions through this intake are limited at reservoir levels below 212.0 feet.[6] Therefore, constrained supplies from Wright Patman Lake should consider 212.0 feet as the lowest current level at which supplies can be diverted. Region D has previously relied on reports from the Texarkana Water Utility that the ability to pull water is impacted at level 223.0. **Riverbend request that an elevation of 212.0' be utilized in all evaluations of constrained water supply affected by the current intake. Furthermore, Region D should recommend a water management strategy for Riverbend to construct a lower water intake to increase the reliability of the current supplies from Wright Patman Lake and be able to more fully utilize the projected firm yield supplies.**

[6] Original intake design has the intake located at an elevation of 210 feet utilizing a 2-foot concrete box, therefore the actual water intake is located at elevation 212 feet.

RECOMMENDATIONS

Riverbend appreciates the hard work of the Region D Water Planning Group, its administrator (Northeast Texas Municipal Water District), and the regional water planning consultants. However, a one-size-fits-all analysis is not appropriate when considering supplies from Wright Patman Lake, which represents fully 2/3 of all firm yield water in the Sulphur River Basin. A more detailed and nuanced approach is needed to accurately characterize its current supply and future supply potential so that the water resources of the Sulphur River Basin can be planned for and managed in the most effective manner possible.

The Riverbend Water Resources District respectfully requests that the Region D Water Planning Group consider the following recommendations regarding the storage capacity, sedimentation rates, and the resulting water supplies available from Wright Patman Lake.

1. To maintain consistency with the current water rights permit and the TCEQ model of the Sulphur River Basin, the Ultimate Rule Curve should be used as the appropriate operating scenario when determining firm yield supplies available from Wright Patman Lake and when analyzing impacts of sedimentation.
2. The recent (2018) bathymetric survey should be utilized to determine the current capacity of Wright Patman Lake, extrapolated to 228.64 feet, to cover the full range of the Ultimate Rule Curve. Riverbend will assist the Region D consultant in performing this extrapolation if it is outside of the current scope of work for Region D.
3. The long-term sedimentation rate should be 680 ac-ft/yr when projecting future storage in Wright Patman Lake. Riverbend will assist the Region D consultant in projecting future reservoir capacities if it is outside the current scope of work for Region D.
4. To maintain consistency with the current water rights permit and the TCEQ model of the Sulphur River Basin, any firm yield analysis of Wright Patman Lake should utilize the full conservation storage and not be limited to storage above elevation 220.0' MSL.
5. Available supplies should be limited to the annual diversions currently authorized by CA 03-4836.
6. Available supply should be further constrained to only those diversions that can be made at elevations allowed by the current intake, with a minimum accessible water surface elevation of 212.0 feet. Riverbend will assist the Region D consultant in performing this analysis if it is outside of the current scope of work for Region D.
7. A water management strategy should be recommended for Riverbend to pursue measures necessary to make the entire firm yield of Wright Patman Lake available for beneficial use.
8. Region D should consider, as a potentially feasible water management strategy, reallocation of flood control storage to conservation storage to further increase supplies from Wright Patman Lake. Riverbend will assist the Region D consultant in performing this analysis if it is outside of the current scope of work for Region D. This will allow additional supply with no construction of additional reservoir storage.