

**APPENDIX B**

**WATER AVAILABILITY MODEL ANALYSES OF  
REGION F WATER SUPPLIES**



## APPENDIX B

**Subject:** Documentation of Region F Water Availability in the Rio Grande Basin

**Date:** March 6, 2018

**Project:** CMD17216

---

This memorandum documents the analyses for the reservoir availability and run of river supplies in the Rio Grande River Basin in Region F. The surface water supplies are based on the hydrology developed for the TCEQ Water Availability Model (WAM). Deviations from these flows were approved in an original letter dated February 9, 2018 and revised letter from the TWDB dated December 16, 2019. The letters authorize several changes to the Rio Grande WAM which are summarized below:

- Modified the Toyah Creek watershed (includes Lake Balmorhea) so that:
  - Water rights located at the San Solomon and Griffin Springs have access to the flows from the springs. This is a correction to an error in the WAM.
  - Excess spring flows (flows not diverted directly from the creek) are directed to Lake Balmorhea for storage in accordance with the Lake Balmorhea water right. The storage would then be modeled as backup for the run of river diversions.
  - Modeling reflects actual operations (upstream to downstream and senior to the rest of the basin to prevent futile priority calls by water rights on the main stem of the Pecos).
- Updated the capacity for Red Bluff Reservoir for 2020 and 2070 sediment conditions.
- Modeled Red Bluff Reservoir as a standalone reservoir by removing backups from Red Bluff Reservoir for downstream diversion by run-of-river water rights.

### B1. TCEQ WAM Run 3

Consistent with TWDB rules and guidelines, existing water supplies in Region F were determined using the TCEQ WAM Run 3 to calculate the firm yield. The model version used for the 2021 Region F supplies was April 14, 2004. This version is consistent with supply evaluations under the current version of the TCEQ WAM Run 3 since 1) the hydrology of the Rio Grande WAM has not been extended and 2) no new water rights have been granted in the Region F portion of the Rio Grande Basin. The following sections describe the process used to determine the availability for each source.

#### B1.1 Lake Balmorhea

Excess water from the San Solomon and Griffin Springs in Pecos County is diverted to Lake Balmorhea for storage and diversion. This portion of the Pecos River was modeled in upstream to downstream order by changing the priority dates to the most senior in the WAM. This reflects actual operation of the basin and prevents run-of-the-river diversions on the Pecos River associated with the Red Bluff Irrigation District from making priority calls on spring flows. In actual operation, the Red Bluff Irrigation District water rights are dependent on releases from Red Bluff Reservoir and do not use or make calls on spring flow from San Solomon or Griffin Springs. Also, it is likely that a priority call on spring flow would be considered a futile call since almost all of the water would be lost before it reached the Red Bluff Irrigation District diversions.

The calculated firm yield of Lake Balmorhea is 18,800 acre-feet per year. A traditional safe yield analysis (safe yield diversion equals minimum storage) was not determined because the reservoir storage is much smaller than the yield (7,400 acre-feet). Because a traditional safe yield analysis was not used, sedimentation conditions were not updated for Lake Balmorhea.

### B1.2 Red Bluff Reservoir

In 2013, the TWDB conducted a volumetric survey of Red Bluff Reservoir. However due to the low water levels an area-capacity-elevation curve all the way to the conservation storage was not calculated. Using the published sedimentation rate in the 2013 TWDB survey and the 1986 survey, 2020 and 2070 sediment conditions were updated from the 2016 RWP.

The total permitted diversion from Red Bluff Reservoir is 292,520 acre-feet per year. This includes multiple run-of-river diversion points downstream of the reservoir. To assess the yield of Red Bluff, releases from Red Bluff were no longer modeled and only diversion directly from Red Bluff reservoir were considered. The firm and safe yields of Red Bluff Reservoir are shown in Table 1. The information used to update sediment conditions for the Red Bluff Reservoir are shown in Table 2.

**Table 1:  
Red Bluff Reservoir Yield**

	Yield (Ac-Ft/Yr)					
	2020	2030	2040	2050	2060	2070
Firm Yield	38,630	38,548	38,466	38,384	38,302	38,220
Safe Yield	30,050	29,980	29,910	29,840	29,770	29,700

**Table 2:  
Red Bluff Sedimentation**

Reservoir	Drainage Area (Sq mi)	Sediment Rate (af/yr/sq mi)	Year of Initial Capacity	Capacities (Ac-ft)			Source (sediment rate)
				Initial	2020	2070	
Red Bluff	20,720	0.01	1925	310,000	279,212	268,758	TWDB, 2013

### B1.3 Run of River Diversions

Forty-eight (48) water right records were identified that are associated with run-of-river irrigation in Region F. Region F defines the reliable supply for irrigation from a run-of-river supply to be the minimum annual diversion. A summary of results is included in Table 3.

**Table 3:  
Pecos River Basin Run-of-River Minimum Annual Diversions**

WUG	Minimum Annual Diversion (Acre-Feet)
Ward County - Irrigation	881
Pecos County - Irrigation	18,672
Reeves County - Irrigation	573
<b>Total</b>	<b>20,126</b>

## APPENDIX B

**Subject:** Documentation of Region F Water Availability in the Colorado Basin

**Date:** February 26, 2018

**Project:** CMD17216

---

This appendix documents the datasets and processes used in the Water Availability Model (WAM) analyses for Region F. The first section of the memorandum pertains to firm yields calculated under the Texas Commission on Environmental Quality (TCEQ) WAM Run 3. Run 3 is the “full authorization” model in which all water rights divert their full permitted amounts and the storage capacities of reservoirs are assumed to be at their full permitted amounts. The second section of this memorandum details the modifications to the WAM as part of the subordination strategy and for determining safe yields.

### **B1. Updated Reservoir Sedimentation Conditions**

For these analyses, the storage volume (SV) and surface area (SA) records of the WAM were modified to reflect sediment conditions in 2020. Another version of the model was created to reflect sediment conditions in 2070. Updated sediment conditions for 2020 and 2070 for all reservoirs in Region F except Mountain Creek, Clyde, and Junction because there was no data. For Winters lake, new sedimentation values were developed for the 2021 Region F Water Plan based on the recent 2013 TWDB survey. Sediment conditions only affect Lake Brownwood and Lake O.H. Ivie under currently available supplies (TCEQ WAM Run 3) because they are the only two reservoirs with yield. The updated sediment conditions were used for all the reservoirs as part of the subordination strategy.

#### ***Winters***

In 2013, the TWDB conducted a volumetric and sedimentation survey of Lake Winters and Elm Creek Reservoir. In the report, it was estimated that Lake Winters has an average loss of capacity of between 7 to 11 acre-feet-per year since impoundment due to sedimentation below the conservation pool elevation. It was estimated that Winters-Elm Creek Reservoir has an average loss of capacity between -3.5 to 11 acre-feet per year. Using the 2013 survey and an overall sedimentation rate of 11 acre-feet per year, 2020 and 2070 sediment conditions were calculated.

Table 1 shows the sedimentation rate used, the source of the rate, the initial capacity and the capacity calculated for 2020 and 2070 for each reservoir in Region F.

**Table 1:  
Sedimentation**

Reservoir	Contributing Drainage Area (sq mi)	Sediment Rate (ac-ft/yr/sq mi)	Year of Initial Capacity	Initial Capacity (Ac-Ft)	2020 Capacity (Ac-Ft)	2070 Capacity (Ac-Ft)
Thomas	934	0.11	1999	200,604	198,460	193,323
Champion	186	0.51	1959	42,492	36,761	33,178
Colorado City	387	0.38	1964	31,967	22,302	14,942
Spence	1,954	0.13	1999	517,272	511,927	499,227
Oak Creek	238	0.50	1953	39,360	31,366	25,416
Ballinger	24	0.17	1985	6,050	5,907	5,703
Elm Creek	64	0.17	2013	7,779	7,704	7,154
Twin Buttes	2,813	0.09	1962	186,200	171,612	158,954
Nasworthy	107	0.16	1993	10,108	9,649	8,793
O.C. Fisher	1,383	0.23	1962	115,743	97,335	81,431
O.H. Ivie	2,792	0.68	1990	554,340	496,757	401,848
Brady Creek	523	0.08	1963	30,430	28,038	25,946
Hords Creek	48	0.36	1948	8,640	7,391	6,527
Coleman	292	0.16	2006	38,094	37,455	35,072
Brownwood	1,181	0.11	2013	136,350	135,422	128,872

## B2. TCEQ WAM Run 3

Consistent with TWDB rules and guidelines, existing water supplies in Region F were determined using a version of the TCEQ WAM Run 3. The supplies were estimated by calculating the firm yield of a given reservoir. The firm yield is the maximum diversion that a reservoir can meet with 100% reliability during a repeat of the drought of record. The changes outlined in this section were approved by the Deputy Executive Administrator of the TWDB on February 9, 2018. This model was received and downloaded from TCEQ on February 5, 2018. Freese and Nichols Inc. performed model runs on in February 2018.

### Lake Brownwood

The following firm and safe yields for Lake Brownwood were developed based on updated 2020 and 2070 sediment conditions.

**Table 2:  
Lake Brownwood Yields**

	2020	2030	2040	2050	2060	2070
<b>Firm Yield</b>						
2021 Plan	24,000	23,820	23,640	23,460	23,280	23,100
<b>Safe Yield</b>						
2021 Plan	18,900	18,760	18,620	18,480	18,340	18,200

### Lake Ivie

The following firm and safe yields for Lake Ivie were developed based on updated 2020 and 2070 sediment conditions.

**Table 3:  
Lake Ivie Yields**

	2020	2030	2040	2050	2060	2070
<b>Firm Yield</b>						
2021 Plan	35,700	34,580	33,460	32,340	31,220	30,100
<b>Safe Yield</b>						
2021 Plan	30,350	29,320	28,290	27,260	26,230	25,200

## B2. Subordination

The subordination strategy (also known as the “no call” assumption) in Region F adopts the cutoff model originally developed by Region K, with a few variations. The modifications made to the WAM as well as the ways in which it differs from the version developed by Region K are outlined below. The changes to the TCEQ WAM for the subordination strategy were approved in a letter from the TWDB Executive Administrator dated October 5, 2018. This model was received from Region K on June 18, 2018 and the analyses were performed by Freese and Nichols, Inc. in July 2018.

### B2.1 Base Dataset

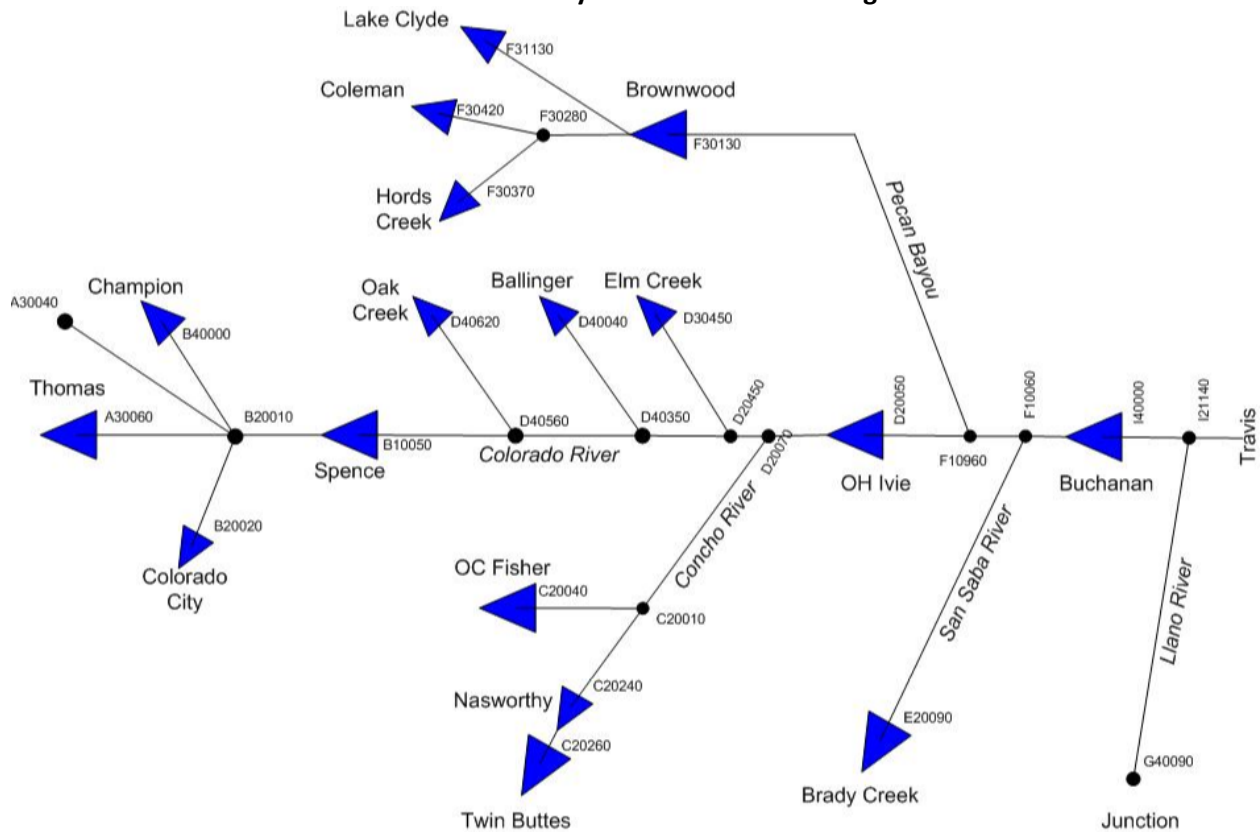
The cutoff model from Region K was used as the base dataset for the safe yield analyses. The cutoff model is a modified version of the Colorado WAM in which water rights at and downstream of Lake Buchanan are subordinated to upstream water rights. The subordination was accomplished by subtracting a value of 10,000,000 from the priority dates of subordinating water rights. For example, a water right with an original priority date of 19580521 would have a priority date of 9580521 after subtracting 10,000,000. After the priority date adjustment, water rights upstream of Lake Buchanan become senior to downstream water rights but maintain their priorities relative to one another. The Region K model has a 77-year hydrologic period-of-analysis from 1940-2016, in contrast to the TCEQ WAM that has a period-of-analysis from 1940-2013.

### B2.2 Record of Modifications

Based on the cutoff model from Region K, one model was developed to simulate 2020 sediment conditions for the safe yield analyses and another was developed to simulate 2070 conditions. The modifications are summarized below and described in greater detail in the remainder of this section.

A schematic of the layout of the reservoirs in Region F is shown in Figure 1.

**Figure 1:  
Schematic of the Layout of Reservoirs in Region F**



The following three modifications were made to each of the major reservoirs in Region F:

- Each reservoir is diverting its safe yield. For a given reservoir, diversions in the safe yield run with the same priority are distributed proportionally to their permitted amounts. If a reservoir has diversions with different priorities, the most senior diversion are met first up to their full permitted amounts before diverting under more junior priority dates.
- Each reservoir has 2020 (or 2070) sediment conditions
- Every reservoir upstream of Lake Buchanan is senior to every reservoir at or below lake Buchanan

### B2.3 Modifications for Each Reservoir

The modifications made for each reservoir are described in more detail below. The reservoirs are listed in the order in which they appear in the TCEQ WAM.

#### Lake Thomas

- In the TCEQ WAM and the Region K WAM, there is a 7,000 ac-ft/yr municipal diversion (WR ID 61401002002) that can be met by either Lake Thomas or Spence Reservoir, and the Type 2 water right for this diversion prohibits refilling of storage.
- In the revised model, the analogous diversion is met by Lake Thomas and refilling storage is allowed (Type 1 water right). The diversion is backed up by Spence Reservoir, but the backup is not triggered because there are no shortages in the safe yield run.



### ***Champion Creek Reservoir***

- In the TCEQ WAM and the Region K WAM, Champion Creek Reservoir is modeled as having 42,500 ac-ft of storage, however the reservoir is only authorized to store 40,170 ac-ft so the WAMs include 2,330 ac-ft of inactive storage.
- After adjusting the reservoir capacity for 2020 sediment conditions, the reservoir capacity is 36,761 ac-ft, which is less than the authorized amount, so the inactive storage was removed.

### ***Lake Colorado City***

- No additional changes, other than those made for all reservoirs, were made to the modeling of Lake Colorado City.

### ***Spence Reservoir***

- The authorized storage in Spence Reservoir is 488,760 ac-ft, although the calculated capacity is greater for both 2020 and 2070 sediment conditions. For this reason, the capacity of Spence Reservoir was left at 488,760 ac-ft in the revised 2020 and 2070 models.
- Whereas in the TCEQ WAM and the Region K WAM, a 7,000 ac-ft/yr municipal diversion (WR ID 61401002002) could be met by either Lake Thomas or Spence Reservoir, the revised modeling has the analogous diversion being met by Lake Thomas and backed up by Spence Reservoir. However, the backup is not triggered during the safe yield run because there are no shortages.

### ***O.C. Fisher Reservoir***

- The authorized storage in O.C. Fisher Reservoir is 80,400 ac-ft, although the calculated capacity is greater for both 2020 and 2070 sediment conditions. For this reason, the capacity of O.C. Fisher Reservoir was changed to 80,400 ac-ft in the revised 2020 and 2070 models.

### ***Twin Buttes Reservoir/Lake Nasworthy***

- Both the TCEQ WAM and the Region K WAM have Lake Nasworthy at Control Point (CP) C20240, however the evaporation is input at CP C20260, a point directly upstream. Within the EVA file, the revised model reassigned the entries for CP C20260 to CP C20240. Lake Nasworthy is still modeled as being at CP C20240.
- Both the TCEQ WAM and the Region K WAM have Twin Buttes Reservoir at Control Point (CP) C20260, although it makes releases for a point upstream (CP C20330). In the revised model, Twin Buttes Reservoir was reassigned to CP 20330.
- The water right ID 61401318001 is associated with an irrigation diversion from Twin Buttes. In the TCEQ and Region K WAMs, it is modeled as a Type 2 water right (no refilling storage). It was changed to a Type 1 water right (with refilling storage) in the revised model.
- There are two priority dates associated with Lake Nasworthy and Twin Buttes Reservoir: 3/11/1929 and 5/6/1959. Consistent with their Certificate of Adjudication, Lake Nasworthy refills are the 1929 priority and Twin Buttes Reservoir refills at the 1959 priority. There is not enough water available from the system to fully meet the 1929 priority diversions, so the diversion amounts for the 1959 priority are set to zero in the safe yield runs.
- Whereas the TCEQ WAM and the Region K WAM includes operational rules enabling one of the two reservoirs to meet a given diversion based on storage contents, these records are removed in the revised modeling in favor of back-ups for the purposes of determining a safe yield for the two reservoirs operated as a system. This allows for cleaner modeling of the priorities of these reservoirs.

### ***Ivie Reservoir (OH Ivie)***

- In the TCEQ WAM and the Region K WAM there is a hide-the-flows “scheme” for subordinating Lake Buchanan to Ivie Reservoir, however that scheme is not necessary in the cutoff model because the water

rights upstream of Lake Buchanan are all senior to water rights at Lake Buchanan and downstream of it. Consequently, WRAP code implementing that scheme was commented out in the revised model.

- In the revised model, Ivie Reservoir is modeled as being subordinate to Lake Ballinger. Ivie Reservoir is on the mainstem of the Colorado and Lake Ballinger is located on an upstream tributary. The subordination is modeled with a backup (BU record) of Ballinger’s water right 61401072302 in the second simulation of the dual simulation (i.e. PX 2).

### **Mountain Creek**

- Mountain Creek is a tributary of the Colorado River. The revised modeling of Mountain Creek Reservoir includes only two of the overall changes discussed previously: diverting its safe yield and subtracting 10,000,000 from its priority date to make it senior to rights at and downstream of Lake Buchanan. Sedimentation conditions for Mountain Creek Reservoir are the same as in the TCEQ and Region K WAMs. The reservoir is small, with only 950 ac-ft of storage according to the TCEQ WAM.

### **Oak Creek Reservoir**

- The TCEQ and Region K WAMs model the Oak Creek Reservoir with 39,360 ac-ft of storage, but because it is only authorized to store 30,000 ac-ft, they include 9,360 ac-ft of inactive storage.
- In the 2016 Plan modeling, sedimentation was assumed to reduce the inactive pool under 2020 conditions. For example, if the 2020 capacity was estimated to be 31,366 ac-ft, then the new inactive storage would be 1,366 ac-ft. However, this approach produces counter-intuitive results for safe yield calculations, in which a year’s supply is left in active storage, because a scenario with 30,000 ac-ft of storage would have a greater yield than a scenario with 31,000 ac-ft of storage and 1,000 ac-ft of inactive storage. For this reason, the Oak Creek Reservoir is modeled as having 30,000 ac-ft of storage capacity with no inactive storage under 2020 conditions. By 2070, the estimated storage capacity is less than 30,000 ac-ft.

### **Lake Ballinger**

- Lake Ballinger is on Valley Creek, a tributary of the Colorado River. The TCEQ WAM includes 4,000 ac-ft of storage for Lake Ballinger at a 1946 priority (the Region K cutoff WAM includes this amount at a 946 priority). However, this amount includes a separate 800 ac-ft impoundment used for sediment control that fills on a non-priority basis, not a 1946 priority. For this reason, the amount of storage associated with the 1946 priority was reduced to 3,200 ac-ft in the revised model.
- Lake Ballinger has additional storage associated with a 1980 priority. In the TCEQ WAM, the total volume of Lake Ballinger increases to 6,050 ac-ft at the 1980 priority (at the 980 priority in the Region K cutoff model). With sedimentation, this amount is reduced to 5,907 ac-ft in 2020 and 5,703 in 2070.
- The revised model also includes code that subordinates Ivie Reservoir to Lake Ballinger. This is implemented with the BU record discussed previously for Ivie Reservoir combined with a PX 2 record associated with Ballinger’s water right 61401072302. The PX 2 record triggers an option that excludes Ivie Reservoir’s control point and all downstream control points in the determination of flow availability for Ballinger’s right.
- The TCEQ WAM has additional code modeling the 800 ac-ft sediment control reservoir at a 2050 priority. The revised model changed this to a priority of 99999999 to make it the most junior in the model.
- There are three senior irrigation diversions and two senior municipal diversions backed up by Lake Ballinger that count toward Ballinger’s safe yield. Because these diversions are senior, their target diversion amounts are met with 100% reliability before iterating on the 1946 diversion amount. Diversion amounts with a priority date later than 1946 are set to zero.

### **Lake Winters (Elm Creek)**

- Lake Winters has a 560 ac-ft/yr diversion and 2,447 ac-ft of storage associated with a 1944 priority. There is an additional 600 ac-ft/yr diversion at a 1957 priority. The permitted storage capacity increases to 8,374 ac-

ft at a 1979 priority. Finally, there is an additional 200 ac-ft/yr diversion at a 1983 priority. In the revised model, the full 8,374 ac-ft storage capacity is reduced to 7,704 ac-ft in 2020 due to sedimentation and to 7,154 ac-ft by 2070. The 2,447 ac-ft of storage at the 1944 priority remains the same in the revised model. The safe yield diversion is calculated for the 1944 priority; the more junior diversions are set to zero.

### ***Brady Creek Reservoir***

- The revised modeling of Brady Creek Reservoir does not include any additional changes, other than the three overall changes made for every reservoir.

### ***Lake Clyde***

- Lake Clyde is on the North Prong of Pecan Bayou, a tributary of Pecan Bayou, which is a tributary of the Colorado River. It is located upstream of Lake Brownwood and is junior in priority to Lake Brownwood. The revised model includes an instream flow requirement (IF record) to pass all water if Lake Brownwood is less than 50% full.
- If Lake Brownwood is greater than 50% full, then Lake Brownwood is subordinated to Lake Clyde. This is accomplished with a PX 2 record associated with Lake Clyde's two water rights (WR IDs 61401660301 and 61401660002). The PX 2 record triggers an option that excludes Lake Brownwood's control point and all downstream control points in the determination of flow availability for Lake Clyde's right.
- In contrast to other reservoirs, the storage capacity and area-capacity relationship for Lake Clyde for both 2020 and 2070 conditions is the same as the Colorado WAM Run 8 (current conditions) due to a lack of information about the sedimentation rate for the reservoir. The storage and area records for Lake Clyde were taken from the FNI archive because Run 8 is no longer available online through the TCEQ website.

### ***Lake Coleman***

- In the revised model, Lake Coleman is modeled similarly to Lake Clyde, which was discussed previously.
- Lake Coleman is on Jim Ned Creek, a tributary of Pecan Bayou, which is a tributary of the Colorado River. It is located upstream of Lake Brownwood and is junior in priority to Lake Brownwood. The revised model includes an instream flow requirement (IF record) to pass all water if Lake Brownwood is less than 50% full.
- If Lake Brownwood is greater than 50% full, then Lake Brownwood is subordinated to Lake Coleman. This is accomplished with a PX 2 record associated with Lake Coleman's two water rights (WR IDs 61401702301 and 61401702302). The PX 2 record triggers an option that excludes Lake Brownwood's control point and all downstream control points in the determination of flow availability for Lake Coleman's right.

### ***Hords Creek Reservoir***

- In the revised model, Hords Creek Reservoir is modeled similarly to Lake Clyde and Lake Coleman, which were discussed previously.
- Hords Creek Reservoir is on Hords Creek, a tributary of Pecan Bayou, which is a tributary of the Colorado River. It is located upstream of Lake Brownwood and is junior to Lake Brownwood. The revised model includes an instream flow requirement (IF record) to pass all water if Lake Brownwood is less than 50% full.
- If Lake Brownwood is greater than 50% full, then Lake Brownwood is subordinated to Hords Creek Reservoir. This is accomplished with a PX 2 record associated with Hords Creek Reservoir's water right (WR ID 61401705301). The PX 2 record triggers an option that excludes Lake Brownwood's control point and all downstream control points in the determination of flow availability for Hords Creek Reservoir's right.

### ***Lake Brownwood***

- Lake Brownwood is located on Pecan Bayou, a tributary of the Colorado River. It is downstream of Lake Clyde, Lake Coleman, and Hords Creek Reservoir, which are all junior in priority to Lake Brownwood.

- The TCEQ and Region K WAMs model Lake Brownwood with 135,963 ac-ft of storage, but because it is only authorized to store 114,000 ac-ft, they include 21,963 ac-ft of inactive storage.
- In the 2016 Plan modeling, sedimentation was assumed to reduce the inactive pool under 2020 conditions. For example, if the 2020 capacity was estimated to be 130,613 ac-ft, then the new inactive storage would be 16,613 ac-ft. In 2070, the estimated capacity was 124,147 ac-ft, which is 10,147 ac-ft greater than the permitted amount. However, this approach produces counter-intuitive results for safe yield calculations, in which a year's supply is left in active storage, because 2070 scenarios with less dead storage have fewer evaporative losses than 2020 scenarios with more dead storage. Furthermore, the Brownwood water right states that the reservoir is "authorized to... impound therein not to exceed 114,000 ac-ft of water." For these reasons, Lake Brownwood is modeled as having 114,000 ac-ft of storage capacity with no inactive storage under 2020 or 2070 conditions.

### **City of Junction**

- The City of Junction has a small on-channel reservoir (300 ac-ft of storage) for which the safe yield was determined. The supply is made reliable by springs located just upstream of the diversion.
- The Region K WAM has the priority of a recreational right at 11/23/1964 and an instream flow requirement and a municipal diversion at 10/14/1986, but in the revised model they are set at 11/23/964 and 10/14/986, respectively, consistent with the assumptions in the rest of the cutoff model.
- In contrast to other reservoirs in which safe yield is determined, the reservoir storage capacity remains at 300 ac-ft for both 2020 and 2070 conditions.

## **B2.4 Priority Date Modification for Additional Water Rights**

A value of 10,000,000 was subtracted from the priority dates for all water rights at and upstream of Junction (G40090) and Brady Creek Reservoir (E20090) using the Hoffpauir Priority Date Modification Tool. The Priority Date Modification Tool, developed by Richard Hoffpauir, consists of an executable program named "Priority" which reads an input file. The input file includes a list of control points along with values to be added or subtracted from the priority dates. The priority dates are modified at the specified control points and all upstream control points.

## **B2.6 Safe Yield Analyses**

A one-year "safe yield" refers to the annual rate at which water may be diverted from a reservoir such that the minimum observed reservoir storage volume through the simulation period-of-analysis is just above the annual diversion rate. For example, the one-year safe yield of Lake Colorado City was estimated to be 1,800 ac-ft/yr and the minimum observed storage content during the simulation was 1,868 ac-ft. The safe yields were evaluated for 17 reservoirs in the Upper Colorado River Basin for 2020 and 2070 conditions of reservoir sedimentation.

The safe yields were determined one reservoir at a time in upstream-to-downstream order, as listed in Table 4. For each reservoir, the diversion amounts for water rights at the reservoir were iteratively reduced until the minimum observed storage in the reservoir through the period-of-analysis was just above (within 100 acre-feet) the total diversion at the reservoir. The safe yield diversion amounts at the upstream reservoir were kept in place while repeating the iterative process for the next downstream reservoir. For reservoirs with multiple water rights with the same priority date, the diversion amounts at each water right were reduced simultaneously while maintaining the same relative ratios as the original authorized diversion amounts. For reservoirs with multiple water rights with varying priority dates, the diversion amount was reduced for the most junior water right first and then for the next most junior water right, and on in this pattern until the safe yield was found.

**Table 4:  
Results of Safe Yield Analyses for 2020 and 2070**

Reservoir Name	Reservoir Identifier	Water Right Identifier	Priority Date	Use Type	Authorized Diversion (ac-ft/yr)	Safe Yield (ac-ft/yr)	
						2020 Scenario	2070 Scenario
Thomas	THOMAS	<b>Total</b>			<b>30,000</b>	<b>3,725</b>	<b>3,610</b>
		61401002301A	9460805	MUN	22,050	2,738	2,653
		61401002301B	9460805	IN1002	950	118	114
		61401002002	9460805	MUN	7,000	869	843
Champion	CHAMPI	<b>Total</b>			<b>6,750</b>	<b>1,170</b>	<b>1,100</b>
		61401009301	9570408	MUN	2,700	468	440
		61401009302	9570408	IN1009	4,050	702	660
Colorado City	COLOCI	<b>Total</b>			<b>5,500</b>	<b>1,800</b>	<b>1,550</b>
		61401009303A	9481122	MUN	2,750	900	775
		61401009303B	9481122	IN1009	2,750	900	775
Spence	SPENCE	<b>Total</b>			<b>34,573</b>	<b>21,575</b>	<b>21,355</b>
		61401008301	9640817	MUN	31,573	19,703	19,502
		61401008302	9640817	IN1008	2,000	1,248	1,235
		61401008303	9640817	MIN	1,000	624	618
Oak Creek	OAKCRK	<b>Total</b>			<b>10,000</b>	<b>1,025</b>	<b>840</b>
		61401031301	9490427	IN1031	4,000	410	336
		61401031302	9490427	MUN	5,328	546	448
		61401031303	9490427	MUN	672	69	56
Ballinger	BALLIN	<b>Total</b>			<b>1,685</b>	<b>785</b>	<b>770</b>
		61401130301	9570225	MUN	60	0	0
		61401072301	9461004	MUN	1,000	160	145
		61401075301	9300207	IRR-D	36	36	36
		61401129302	9290306	MUN	49	49	49
		61401073301	9250406	IRR-D	40	40	40
		61401129301	9140611	MUN	450	450	450
Elm Creek-Winters	ELMCRK	<b>Total</b>			<b>1,360</b>	<b>175</b>	<b>175</b>
		61401095304	9830207	MUN	200	0	0
		61401095302	9570605	MUN	600	0	0
		61401095301	9441218	MUN	560	175	175
Twin Buttes <sup>1</sup>	TWINBU	<b>Total</b>			<b>29,000</b>	<b>0</b>	<b>0</b>
		61401318002	9590506	MUN	4,000	0	0
		61401318001	9590506	IRR-C	25,000	0	0
Nasworthy <sup>1</sup>	NASWOR	<b>Total</b>			<b>25,000</b>	<b>3,340</b>	<b>2,865</b>
		61401319002	9290311	MUN	17,000	2,271	1,948
		61401309003	9290311	IND	7,000	935	802
		61401319001C	9290311	IRR-C	1,000	134	115
O. C. Fisher	OCFISH	<b>Total</b>			<b>80,400</b>	<b>1,320</b>	<b>755</b>
		61401190001	9490527	MUN	80,400	1,320	755
O. H. Ivie	OHIVIE	<b>Total</b>			<b>113,000</b>	<b>32,340</b>	<b>28,120</b>
		11403676301	9780221	MUN	103,000	29,478	25,632
		11403676302	9780221	IN3676	10,000	2,862	2,488
Mountain Creek	R1024A	<b>Total</b>			<b>250</b>	<b>70</b>	<b>70</b>

Reservoir Name	Reservoir Identifier	Water Right Identifier	Priority Date	Use Type	Authorized Diversion (ac-ft/yr)	Safe Yield (ac-ft/yr)	
						2020 Scenario	2070 Scenario
		61401024301	9491216	MUN	250	70	70
Brady Creek	BRADYC	<b>Total</b>			<b>3,500</b>	<b>1,950</b>	<b>1,750</b>
		61401849001	9590902	MUN	3,000	1,671	1,499
		61401849002	9590902	IND	500	279	251
Hords Creek	HORDSC	<b>Total</b>			<b>2,240</b>	<b>180</b>	<b>146</b>
		61401705301	9460323	MUN	2,240	180	146
Coleman	COLEMA	<b>Total</b>			<b>9,000</b>	<b>1,792</b>	<b>1,692</b>
		61401702301	9580825	MUN	4,500	896	846
		61401702302	9580825	IN1702	4,500	896	846
Clyde	LCLYDE	<b>Total</b>			<b>1,200</b>	<b>75</b>	<b>75</b>
		61401660002	9850906	MUN	200	0	0
		61401660301	9650202	MUN	1,000	75	75
Brownwood	BROWNW	<b>Total</b>			<b>29,712</b>	<b>24,340</b>	<b>23,770</b>
		61402454301	9250929	MUN	15,996	13,104	12,797
		61402454302	9250929	IN2454	5,004	4,099	4,003
		61402454303	9250929	IRR-F	8,712	7,137	6,970
Junction	G40090	<b>Total</b>			<b>1,000</b>	<b>250</b>	<b>250</b>
		61401570002	9861014	MUN	1,000	250	250

1. Twin Buttes and Nasworthy are operated as a system and their safe yields should be added.