Technical Memorandum for the Upper Red River Basin Study

Cable Mountain Reservoir Hydrology and Costs

FINAL

Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Introduction

Cable Mountain Reservoir is a proposed reservoir site located on the North Fork Red River (NFRR) about 40 miles downstream of Lugert-Altus Reservoir and below the confluence of the Elm Fork of the Red River and Elk Creek (Figure 1). The reservoir site was first identified by the Oklahoma Water Resources Board (OWRB) in a 1967 planning report on water resources in western Oklahoma. In the report, the Cable Mountain reservoir site, referred to as the "Navajo" site, was identified as a potential source of irrigation water for the region, including Lugert-Altus Irrigation District (ID), supplying an average annual yield of about 108,000 acre ft/yr. Although the reservoir has never been built, interest in its development has continued for decades. The most recent analysis by Reclamation on Cable Mountain was completed in 2005 as part of a broader appraisal-level investigation into alternatives to augment water supplies to Lugert-Altus Reservoir (Reclamation, 2005). Reclamation's appraisal investigation concluded that Cable Mountain had the potential to yield an abundant supply of water to the region, but the water was highly saline, and the costs to build, operate, and maintain the reservoir rendered the reservoir cost-prohibitive relative to other potential supply alternatives. Nevertheless, interest in Cable Mountain has continued, prompting stakeholders to ask Reclamation to update the preliminary costs estimates and conduct new modeling to determine the water supply that could be yielded from the potential reservoir. These results are provided below.

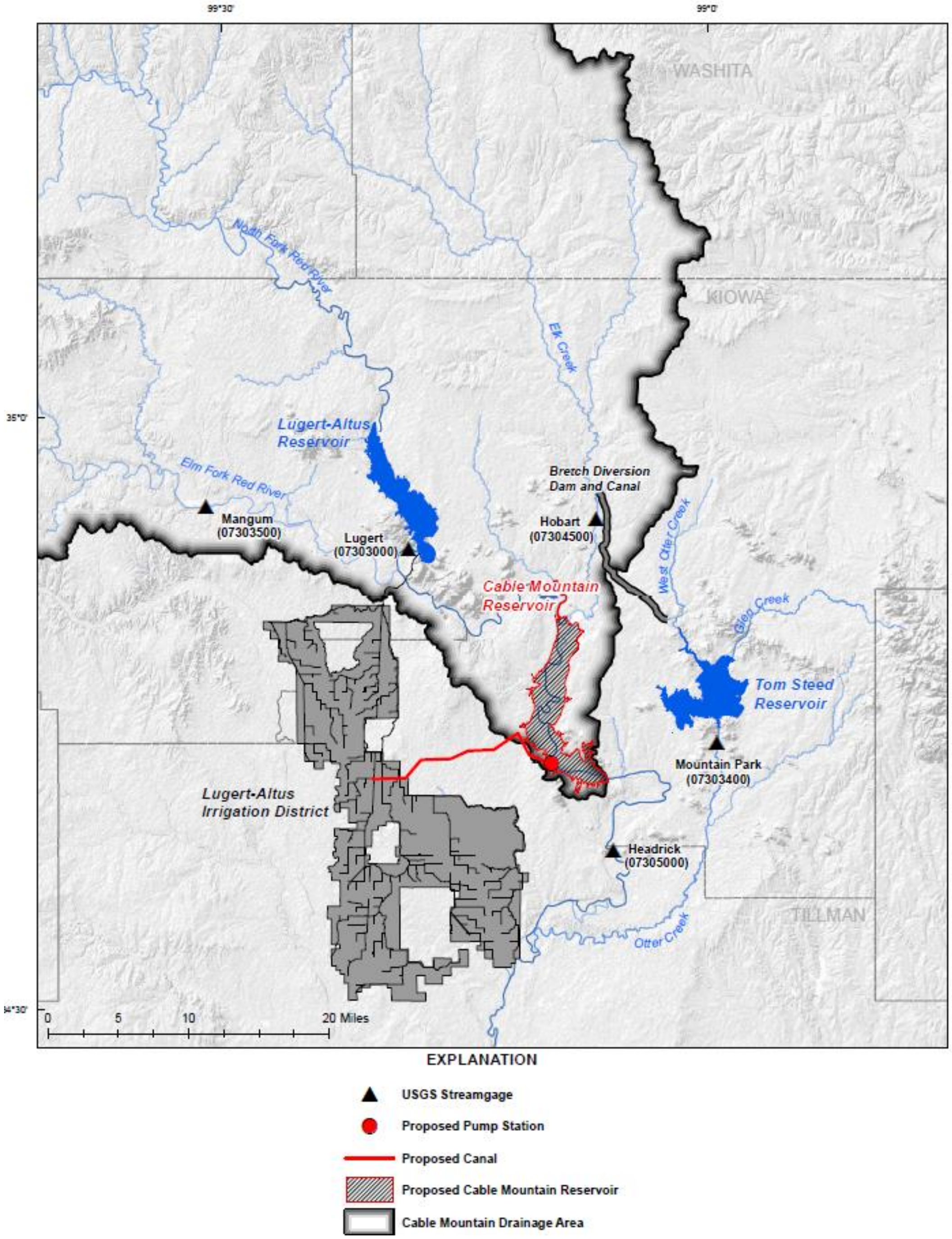

Figure 1. Proposed location of Cable Mountain Reservoir and conveyance canal to Lugert-Altus Irrigation District.

Hydrology and Reservoir Yield

Approach

The proposed location of Cable Mountain Dam and Reservoir is on the NFRR below Lugert-Altus Reservoir and below the confluence of the NFRR with both the Elm Fork of the North Fork of the Red River (Elm Fork Red River) and with Elk Creek; it is located about five river miles upstream of the Headrick streamgage [(USGS 07305000) (Figure 1)]. A reservoir yield model was developed to simulate yield and water supply dependability of Cable Mountain Reservoir. The model was comprised of a mass balance equation developed in Microsoft Excel that simulated inputs (e.g., inflow, precipitation) and outputs (e.g., evaporation, sedimentation, deliveries) on a monthly time step.

Reservoir inflows were calculated using Headrick streamgage data recorded over a 65-yr period between Jan 1951 and Dec 2016. The year 1951 was selected as the beginning of the period of record because this was the first year after initial irrigation deliveries began following construction of Lugert-Altus Reservoir on the NFRR. Monthly divertible flows from Elk Creek to Tom Steed Reservoir, as calculated in accordance with methods described in Reclamation (2022) (Appendix 6.2, Elk Creek Divertible Flow), were subtracted from the Headrick streamgage flow record. Elm Fork Red River flows were not adjusted because no impoundments exist on the Elm Fork Red River. The drought of record was found to occur between Sept 2007 and May 2015. A full list of model inputs, data sources, and assumptions is provided in Table 1.

Table 1. Inputs and data sources for the reservoir yield model developed to estimate potential water availability from Cable Mountain Reservoir.

Model Input	Data Source	Dates Available
Inflow:		
Inflow equals USGS Stream Gage (adjusted proportionally for drainage area difference) minus the maximum divertible flows from Elk Creek to Tom Steed Reservoir	USGS Stream Gage 07305000 North Fork Red River near Headrick, OK (mean daily flow)	Jan 1951 – Dec 2016
	Reclamation's Reservoir Yield Model for Tom Steed Reservoir	Jan 1951 – Dec 2016
Net Evaporation:		
Calculated based on pre-construction evaporation estimates and measured pan evaporation rates at Tom Steed Reservoir. Multiplied post-construction pan evaporation measurements from Tom Steed Reservoir by a free surface coefficient factor of 0.7 (Kohler et. al., 1955), and then multiplied by reservoir surface area to obtain monthly evaporative losses out of Cable Mountain Reservoir.	Plan of Development for Mountain Park Project, Oklahoma: Appendix A, Table A-21, "Mountain Park Reservoir Net Evaporation Rate (inches)".	Jan 1951 – Sept 1959
	Mountain Park Water Supply Report, Total Monthly Pan Evaporation times free surface coefficient (0.7) and previous months reservoir surface area.	Oct 1959 – Dec 2016
Sedimentation:		
Reservoir Area and Capacity	Developed using the ACAP-32 Program based on 5-ft contours from the 2016 USGS Topographic Survey.	
Sediment distribution	Assumed year 2060 sediment conditions and a sedimentation rate of 414 acre-ft/yr, which is the rate calculated by Reclamation for Lugert-Altus Reservoir based on its 2007 Sediment Survey 417 ac-ft/yr.	
Seepage:		
Assumed 300 acre-ft per month over the period of record, which was the largest of the pre-construction seepage estimates for three Reclamation earthen dams in Oklahoma (i.e., Fort Cobb Reservoir, Foss Reservoir, and Lake of the Arbuckles).		
Annual Municipal & Industrial (M&I) Delivery Distribution:		
Assumed a monthly distribution of M&I deliveries based on observed deliveries from Tom Steed Reservoir	Mountain Park Master Conservancy District Water Supply Report	Jan 1979 – Dec 2016
Annual Irrigation Delivery Distribution:		
Assumed a monthly distribution of irrigation deliveries based on observed deliveries from Lugert-Altus Reservoir.	Lugert-Altus Irrigation District Water Supply Report	Jan 1951 – Dec 2016
Downstream Release Requirements:		
Environmental mitigation	None	
Senior downstream water rights	None	

Results

The reservoir yield model was used to calculate the 80 percent and 98 percent dependable yields of Cable Mountain Reservoir. These are the dependable yields considered under Oklahoma regulations (OAC 785:20-5-5) for the appropriation of water out of a reservoir for irrigation and M&I purposes, respectively. A 100 percent dependable firm yield also was calculated.

Modeling results showed that the 80 percent dependable yield of Cable Mountain Reservoir for irrigation purposes was 60,700 acre-ft/yr (Figure 2). Assuming an annual irrigation demand of 60,700 acre-ft/yr, the average annual yield of Cable Mountain Reservoir was estimated to be 54,800 acre-ft/yr. The firm yield was estimated to be 23,700 acre-ft/yr.

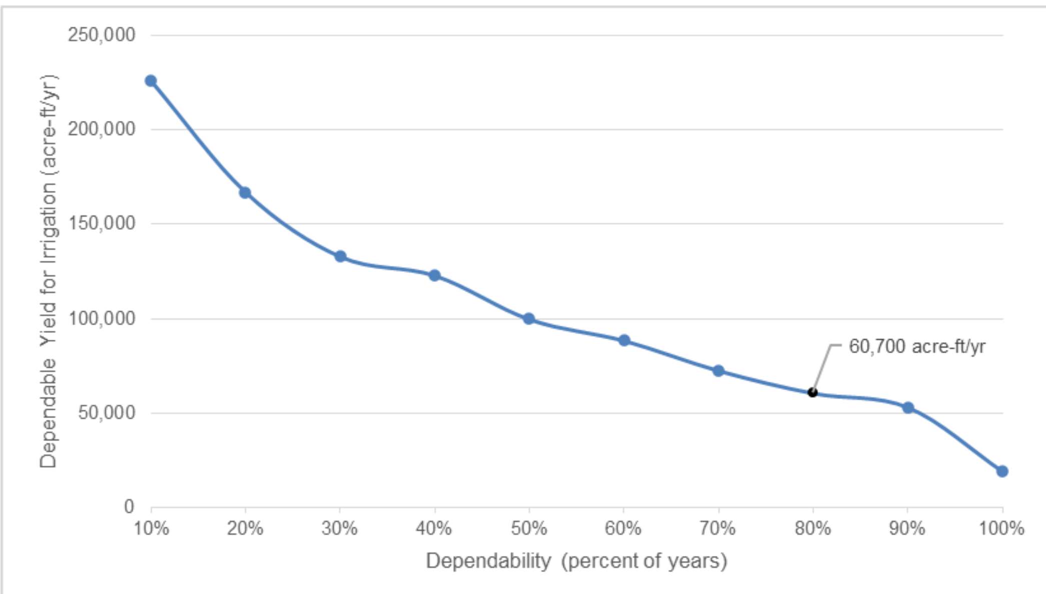

Figure 2. Range of dependable yields for irrigation purposes from Cable Mountain Reservoir, 2060 sediment conditions.

Infrastructure Design Narratives and Assumptions

Cable Mountain reservoir was assumed to be comprised of three main project features: (1) dam; (2) pumping plant; and (3) conveyance canal to the Lugert-Altus ID. General design narratives for each project feature are provided below. Detailed quantity sheets are located in Reclamation OTAO's central files and are available upon request. Several key assumptions used in developing cost estimates are cited below.

Cable Mountain Dam

The dam would be an earthen structure with two dikes to contain the reservoir body. The dam would have a maximum elevation of 1,430 ft, a maximum height of 80 ft above the stream bed, and a storage volume of approximately 413,000 acre-ft. The reservoir would inundate approximately 11,000 acres of land. The length of the dam would be approximately 2,400 ft with a crest width of 30 ft. A cut-off trench approximately 80 ft in length and 20 ft deep was assumed to be needed through the river section. The construction of the dam and dikes would require 1.65 million and 270,000 cubic yards of fill, respectfully. The location and dimensions of the dam and dikes, as well as reservoir pool size, were determined using Google Earth. Specific features such as the spillway, outlet works, drains, etc. were inferred based on similar-type reservoirs evaluated in the development of cost estimates provided below.

Pumping Plant

An open air pumping plant would be located on the south shore of Cable Mountain Reservoir immediately northwest of the granite outcrop near the town of Cable Mountain. The pumping plant would lift water about 75 vertical feet from the reservoir to the head of a gravity-flow canal through two 2,000-ft parallel pipelines sized to deliver a total of 600 cfs on the west side of the proposed reservoir. The pumping plant would include an intake and pipe discharge into an open canal.

Canal

A 12.5-mile open canal would convey water to the middle portion of the Lugert-Altus ID (Figure 1). The alignment and topography for the canal were developed in Google Earth. The canal would be lined with a 20 mm PVC liner and covered with four inches of concrete. Earthfill quantities were developed using a balanced cut/fill for the length of the canal. The dimensions were as follows: Base (10 ft); height (10 ft); side slopes (1.5 ft to 1 ft); water depth (7.5 ft); and drop (0.25 ft per mile).

Cost Estimate

Cost estimates were prepared by Reclamation's Oklahoma-Texas Area Office (OTAO) to "preliminary' standards as defined by Reclamation's Directives and Standards (D&S) Cost Estimating (FAC) 09-01[1] (Table 2). Preliminary cost standards are considered the most basic planning-level costs and are intended to be for comparative purposes only. Development of these estimates does not imply support by Reclamation for project authorization or any specific language in an appropriation bill. All costs were developed in 2016 dollars primarily using RS Means, edition 2016. Costs were then indexed to 2021 using Reclamation's construction cost trend modeling.[2]

Contract, non-contract, and contingency costs (i.e., for unexpected or unknown conditions, circumstances, etc.) were comprised of the following: mobilization (5 percent); design contingencies (15 percent); procurement strategies (3 percent); construction contingency (25 percent); planning (5 percent), designs and specifications (4 percent); and construction management (1 percent). Environmental mitigation costs were assumed to equal the cost of land acquired to construct the reservoir. Operations and maintenance (O&M) of the main project features were derived primarily from existing O&M costs of existing dams and reservoirs within OTAO. Pumping plant O&M costs included electricity, labor,

[1] https://www.usbr.gov/recman/fac/fac09-01.pdf.
[2] https://www.usbr.gov/tsc/techreferences/mands/cct.html.

and equipment maintenance. Power costs were estimated using the average power cost in Oklahoma for industrial customers.

Table 2. Capital costs and operations and maintenance costs of Cable Mountain Reservoir. Costs are considered "preliminary" in accordance with Reclamation's Cost Estimating Directives and Standards FAC 09-01. Costs do not include salinity control.

Project Cost Components	July 2016 RS Means	2016 Cost Indexed to July 2021[5]
Dam and Reservoir	$82,100,000	$98,600,000
Pumping Plant	$35,623,000	$41,400,000
Canal	$20,250,000	$24,100,000
Land Acquisition Cost	$55,900,000	$66,000,000
Subtotal	*$193,900,000*	*$230,000,000*
Contract Costs[1]	$44,600,000	$53,000,000
Subtotal	*$238,500,000*	$283,000,000
Construction Contingencies[2]	$59,600,000	$70,800,000
Subtotal	*$298,100,000*	*$353,800,000*
Non-Contract Costs[3]	$29,800,000	$35,000,000
Environmental Mitigation[4]	$55,900,000	$66,000,000
Total Construction Cost	**$384,000,000**	**$455,000,000**
Annual O&M Cost	$2,060,000	$2,500,000

[1] Contract costs (23%) includes: Mobilization (5%), Design Contingencies (15%), and Procurement Strategies (3%)
[2] Construction Contingency (25%)
[3] Non-Contract costs (10%) include: Planning (5%), Designs and Specifications (4%), Construction Management (1%)
[4] Environmental compliance and mitigation costs were assumed to be equal to the land acquisition costs.
[5] Indexed using Reclamation Construction Cost Trends (https://www.usbr.gov/tsc/techreferences/mands/cct.html)

Chloride Control

A significant challenge that should be considered when assessing the viability of Cable Mountain Reservoir relates to water quality. Reclamation's analysis of Cable Mountain Reservoir did not consider the costs to treat and remove the high concentration of chlorides that are known to exist in the Elm Fork of the NFRR upstream of Cable Mountain Reservoir. The source of the chlorides, known as "Area VI", is comprised of brine sources from three canyons along the south bank of the Elm Fork about three miles east of the Texas-

Oklahoma State line, the drainage area of which is about seven square miles with a chloride load of about 510 tons per day (U.S. Army Corps of Engineers, 2012). The USACE has performed numerous studies on chloride control in the area over the years dating back to the 1950s. In 2004, following Federal appropriations and a request by the Oklahoma governor to re-evaluate chloride control measures at Area VI, the USACE re-initiated investigations into chloride control at Area VI above Cable Mountain Reservoir.

Around the same time, Reclamation completed a preliminary evaluation of chloride control at Area VI as a necessary component to enhance the feasibility of Cable Mountain Reservoir in its 2005 investigation into alternatives to augment the supplies to Lugert-Altus ID (Reclamation, 2005). The method of brine control conceptualized in this alternative included intercepting the flow at the salt emission area and transferring it off-site by a pump station and pipeline for disposal by deep-well injection. Reclamation (2005) concluded that effective control of salt loading in the Elm Fork of the NFRR would be critical towards determining whether water stored in Cable Mountain Reservoir could be suitable for beneficial uses.

Meanwhile, the USACE continued its detailed investigation into chloride control measures at Area VI, but the study was moved to inactive status by the USACE in 2013 after funds were exhausted, at which point the USACE published a report in September 2012 titled, "Area VI Feature Reevaluation, Feasibility Scoping Meeting Document, Chloride Control Project, Texas, Louisiana, and Oklahoma[3]. The 2012 USACE report contains a detailed chronology of chloride control activities in the Red River Basin, including at Area VI. It also contains results of the USACE's analysis on Area VI, including its findings on the problems and needs, future with- and without-project conditions, planning objectives, and a range of proposed collection and disposal alternatives to reduce chlorides from 510 tons per day to 400 tons per day. The USACE 2012 report did not include estimated costs to implement chloride control at Area VI.

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3 https://www.swt.usace.army.mil/Portals/41/docs/library/chloride_control/Area_VI_Reevaluation_Report_for_FSM_28Sep2012_withCorrespondence.pdf.

Red River Compact

Another potential challenge associated with Cable Mountain Reservoir relates to the Red River Compact (Compact). The Compact was signed by member states in 1978 to resolve and prevent disputes over waters of the Red River Basin that are shared between the neighboring states of Arkansas, Louisiana, Oklahoma and Texas, and to assure the receipt by member states of adequate surface flows and releases. While provisions of the Compact specifically state how much water each state is allowed to develop or store on an interstate stream, the Compact generally provides a means of working out problems between member states in an orderly manner, thus preventing the likelihood of litigation in most cases. As part of the Compact, the Red River is divided into "Reaches" both above and below Lake Texoma (Figure 3). Reach I, upstream of Lake Texoma, is further divided into three subbasins, with Subbasin I containing the NFRR which flows across the Texas state border into Lugert-Altus Reservoir in Oklahoma. According to Section 4 of the Compact, 60 percent of the surface waters in Subbasin I are apportioned to Texas and 40 percent to Oklahoma. In so far as the development of the apportioned water resources in Texas could affect inflow to Cable Mountain Reservoir, projected growth and planned development of water resource activities within Subbasin I should be considered when assessing the viability of Cable Mountain Reservoir. According to the Texas Region A Water Plan (Freese and Nichols Inc. et al, 2015), which encompasses Subbasin I, little to no growth is projected in this area, water supplies are provided almost exclusively by groundwater, and development of surface water supplies are not anticipated. However, if Texas developed its entire Compact apportionment, the water supply of Cable Mountain Reservoir could be significantly reduced.

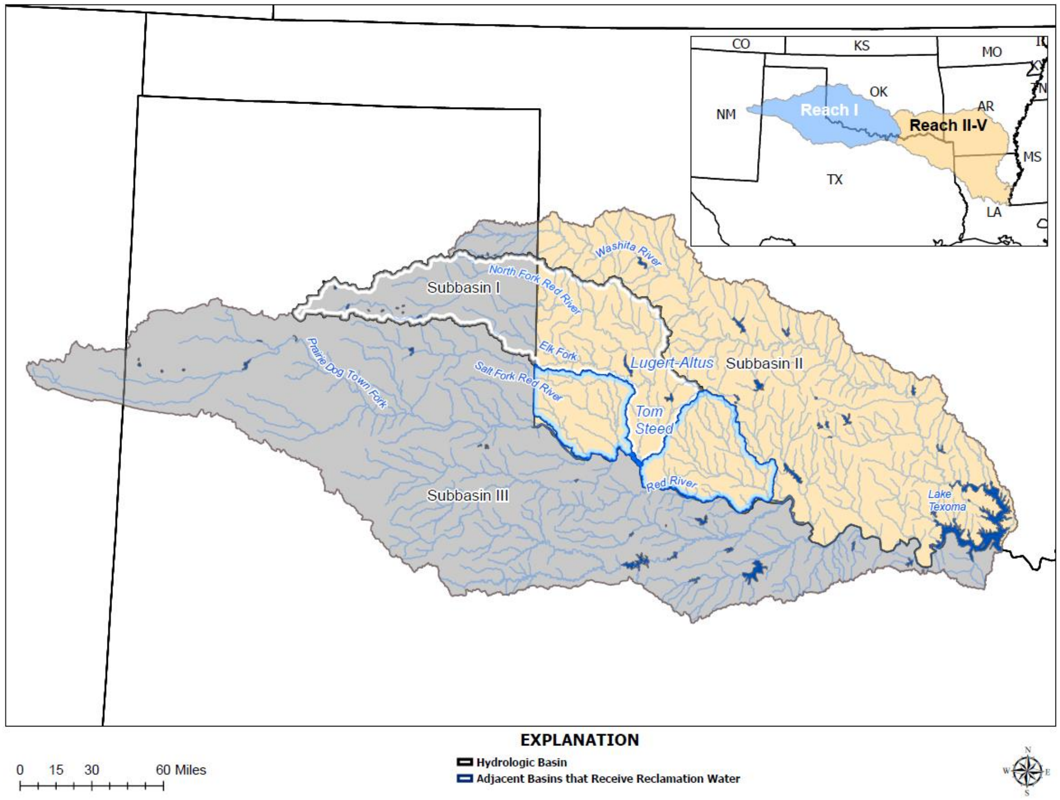

Figure 3. Subbasins I-III of Reach I of the Red River Compact.

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