2024 Dallas Long Range Water Supply Plan

City of Dallas, Texas

October 1, 2024

This Page Intentionally Left Blank.

INITIALLY PREPARED DRAFT

2024 Dallas Long Range Water Supply Plan

Prepared for:

Dallas Water Utilities

City of Dallas, Texas

This document is released for review purposes only under the authority of Adam Cory Shockley (TX-PE 94761), HDR Engineering, Texas Registered Firm F-754.

Prepared by:

HDR Engineering

In association with:

Maddaus Water Management

October 2024

This Page Intentionally Left Blank.

2024 Dallas Long Range Water Supply Plan

City of Dallas, Texas

October 1, 2024

This Page Intentionally Left Blank.

INITIALLY PREPARED DRAFT

2024 Dallas Long Range Water Supply Plan

Prepared for:

Dallas Water Utilities

City of Dallas, Texas

This document is released for review purposes only under the authority of Adam Cory Shockley (TX-PE 94761), HDR Engineering, Texas Registered Firm F-754.

Prepared by:

HDR Engineering

In association with:

Maddaus Water Management

October 2024

This Page Intentionally Left Blank.

Table of Contents

Figures

Tables

Appendices

1 Introduction

1.1 Authorization

The City of Dallas' current Long Range Water Supply Plan shows the need to obtain and connect additional water supply in order to meet the future needs of the residents and customers of Dallas and that engineering services are required to:

- review current conditions,
- analyze the need for revisions to the current planning area,
- update population and water demand projections,
- analyze the impact of water conservation on demand planning,
- compare alternative supply sources (water conservation, reuse, surface water and groundwater) and treatment facilities needed to meet demand,
- and to recommend a plan of action that would allow the City to provide for the needs of its customers to the year 2080.

In January 2023, the City of Dallas retained HDR Engineering, Inc. (HDR) to develop the 2024 Dallas Long Range Water Supply Plan (2024 LRWSP). The development of the 2024 LRWSP was authorized under Contract No. 22-169E as approved at the November 9, 2022, Dallas City Council meeting.

This plan will build on efforts for long rang water supply planning dating back to the 1950s and specifically updates assumptions and actions taking since the 2014 LRWSP.

1.2 Objectives and Scope

The last full review of Dallas' Long Range Water Supply plan is contained in the 2014 Long Range Water Supply Plan (2014 LRWSP). The Region C planning cycle required Dallas to provide a list of Recommended and Alternative Water Management Strategies (WMS) to the Region C Regional Water Planning Group (RWPG) in late 2014 for inclusion in the 2016 Region C Regional Water Plan (RWP). The Region C plan was updated in 2021 and is currently being updated for the 2026 cycle. Dallas realized the need to update its water supply plan to not only be consistent with the Region C planning effort, but to update the 2014 LRWSP utilizing new planning data to provide a greater level of specificity for Dallas to quantify demands, update supplies and verify, evaluate, and plan for the implementation of future water management strategies. These efforts to update the Long Range Water Supply Plan for Dallas are summarized in the 2024 Long Range Water Supply Plan. The objectives of the 2024 LRWSP are to:

- Update population and water demand projections through 2080 considering revisions to Dallas' service area,

- Review current and future supply quantities from existing supplies through 2080,
- Analyze the impact of water conservation on demand,
- Evaluate previously recommended and alternative water management strategies for updated costs, supplies, and viewed through an equity lens,
- Identify treatment, transmission, and other infrastructure needs resulting from plan implementation, and
- Define an implementation plan for the recommended strategies.

The scope of work for the development of the 2024 LRWSP includes the following tasks to accomplish the above objectives:

- Collecting and analyzing data from previous studies including recent DWU water use and wastewater discharge data,
- Developing population forecasts and future estimates of water demands and wastewater discharges,
- Evaluating current and estimated future supply from existing sources considering the potential effects of a warmer climate on reservoir evaporation and yields,
- Evaluating the impact of Federal / State regulations and permitting requirements on water management strategy implementation,
- Evaluating, ranking and selecting future water supply strategies,
- Identifying infrastructure requirements and integration plans, and
- Developing implementation plans for recommended strategies and preparation of a report.

The result of this effort is the development of the 2024 LRWSP for Dallas to meet the demands of its residents and customers through 2080.

1.3 Background and Previous Studies

Following the severe drought of the 1950s, Dallas' water supply planning and development efforts resulted in Dallas securing water from numerous sources to meet immediate and long-term demands. Today, Dallas continues to be a leader in the North Texas region in the planning for and development of additional water supplies. The City of Dallas has developed a series of long-range water supply plans starting in 1959 and continuing in 1975 and 1989, with updates occurring in 2000 and 2005. The most recent comprehensive plan being the 2014 LRWSP. Dallas' previous plans serve as the building blocks upon which the current LRWSP has been developed. Table 1-1 provides a summary of previous studies.

Table 1-1. Previous studies referenced during the development of the Dallas 2024 LRWSP

Study Name	Study Date	Study Focus
Long-Range Water Supply Study for the City of Dallas	January 1959	Long Range Water Planning
Long Range Water Supply Study	March 1975	Long Range Water Planning
Long-Range Water Supply Plan 1990-2050	December 1989	Long Range Water Planning
2000 Update Long Range Water Supply Plan	November 2000	Long Range Water Planning
2005 Update Long Range Water Supply Plan	December 2005	Long Range Water Planning
2006 Region C Water Plan	January 2006	Regional Water Planning
2011 Region C Water Plan	October 2010	Regional Water Planning
2016 Region C Water Plan	January 2016	Regional Water Planning
2021 Region C Water Plan	January 2021	Regional Water Planning
DWU Wastewater Treatment Facilities Strategic Plan	December 2010	Wastewater Infrastructure
Integrated Pipeline Project Conceptual Design Operations Study Final Report	April 2012	Lake Palestine Supply
Water Capital Infrastructure Assessment & Hydraulic Modeling	July 2007	Treated Water Distribution System
Water Conservation Five-Year Strategic Plan	June 2010	Water Conservation
Sulphur River Basin Wide Feasibility Study	On going	Sulphur Basin Water Supply Strategies
Upper Neches River Water Supply Project Feasibility Study	February 2015	Upper Neches Water Supply Strategies
Historic and Future Demand Projections of DWU Wastewater Facilities Operations and Strategic Plan	2014	Wastewater System
DWU Water Production Facilities Strategic Plan	2024	Water Production Facilities for DWU
ForwarDallas: Comprehensive Plan	2024	Comprehensive Plan

1.4 Study Methodology

Dallas' 2024 LRWSP follows the methodology used in the development of Dallas 2014 LRWSP with a few minor exceptions. The 2014 LRWSP focused on updating all of Dallas' planning data with a deep dive into water supply strategy identification, evaluation, and selection. The 2024 LRWSP provides an update to the recommended and alternative strategies from the 2014 plan but incorporates significant effort above that of the 2014 plan to build up the population and water demands for the City of Dallas using internal data and not relying solely on the Texas Water Development Board (TWDB) planning data. Section 2 of this plan includes a review of Dallas' service and planning area. Sections 3 and 4 describe how future water demands are estimated using population projections and historic water use, City of Dallas planning data, and trends as provided by the TWDB for the 2026 Region C RWP. Figure 1-1 is a map from the TWDB showing the Regional Planning Areas. Dallas is located in Region C. Section 5 includes current and future estimates of supply for each of Dallas' existing supply sources. In Section 6 future demands are compared against the estimates of future supply to determine Dallas' needs through 2080 and includes the recommended strategies to meet these needs. Section 7 includes evaluations of the strategies, and the associated ranking and selection process used to identify these strategies. Section 8 presents recommendations for needed infrastructure improvements and the implications of implementing the plan on Dallas' existing treatment and distribution infrastructure. Section 9 provides conclusions, recommendations and implementation plans for recommended strategies.

The 2024 LRWSP takes a more detailed approach to analyzing population, demands, and current supply yields by incorporating the models described in the following paragraphs.

The 2024 LRWSP builds up population and water demands for the City of Dallas utilizing Dallas' own planning data. This change in planning approach provides Dallas a much more detailed plan than provided at the TWDB regional planning level. Additionally, while estimates of current and future supply available from Dallas sources developed for the 2024 LRWSP are similar to those developed for the 2026 Region C RWP, more emphasis is placed on Dallas' operating policies and methods when applying various modeling assumptions.

Population and water demand for the City of Dallas were evaluated using two new tools developed specifically for Dallas to use in this and future planning efforts. A population forecast model was developed that relies on publicly available data and user inputs to estimate current and project future City of Dallas populations. The Population Forecast Model was developed to estimate current and project future population totals using a variety of input parameters, customized for DWU. The Population Forecast Model was built utilizing pressure zone and census boundaries, historic population and housing data, land use capacity data, including zoning data and ForwardDallas Place Type data. This tool allows Dallas to track future population estimates against the projections used in this plan and the ability to update population forecasts based on changing demographic data.

A similar tool was developed for water demand and conservation. The Demand Side Management Least Cost Planning Decision Support System Model (DSS Model) was utilized to evaluate water production for specific end uses to produce retail customers water use. Data included in the DSS Model consists of historical system production, plumbing codes, water conservation efforts, water rates, weather (rainfall and temperature), population mix, unemployment rate, and other approved and verified data. These models will assist DWU in the continuous evaluation of recommended and alternate strategy implementation. This model also allows Dallas to track future performance against planned projections to see how demand is tracking against what was planned for in the 2024 LRWSP.

The water supply modeling assumptions consider findings from a comprehensive review of Dallas' water rights and result in a greater level of detail than what is found in the Region C RWP. Reservoir yields were calculated using Dallas' RiverWare[1] model

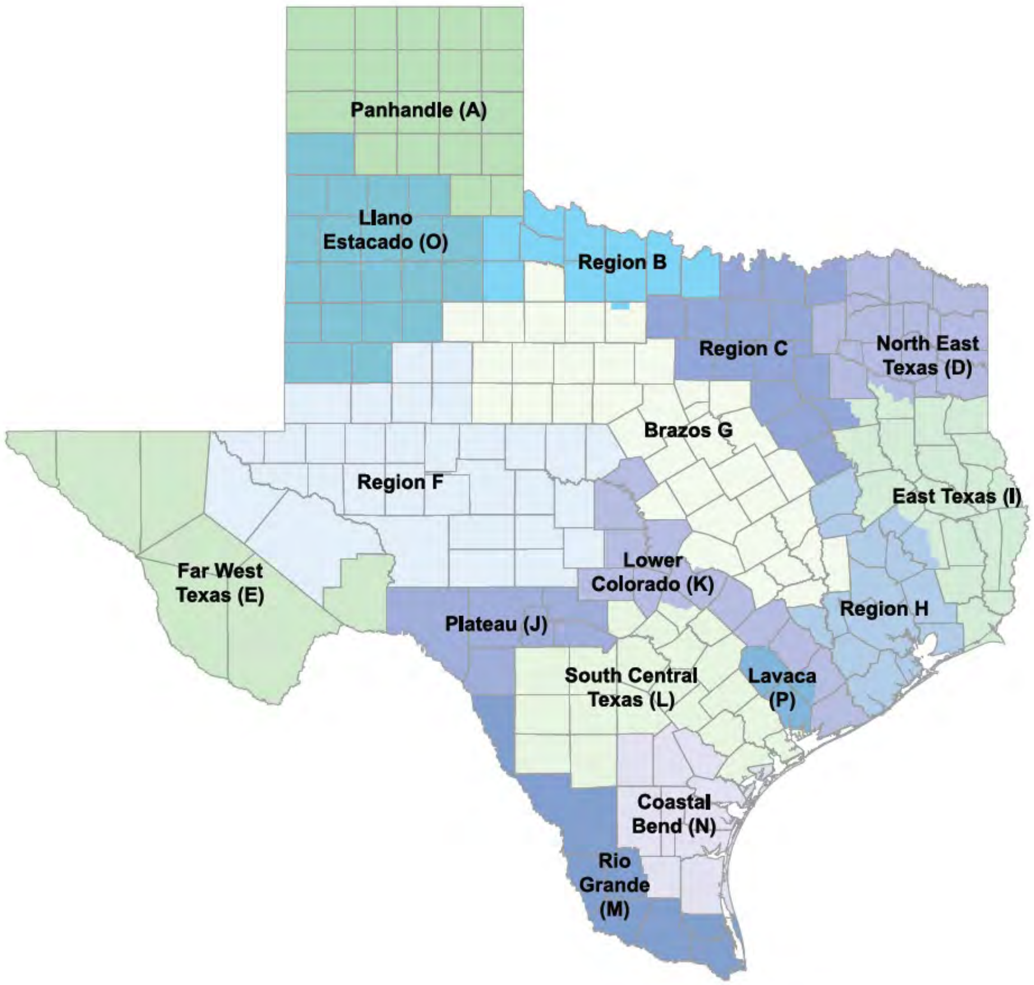
[1] The Dallas RiverWare Model, also referred to as the Dallas Model, was developed by HDR as a decisions support tool to simulate Dallas reservoir operations, drought mitigation response, and to evaluate the reliability of Dallas' existing and future water supply sources. The model utilizes the RiverWare software package developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of

developed by HDR for Dallas as part of the Dallas Water Utilities / Tarrant Regional Water District Integrated Pipeline project (IPL). The Dallas RiverWare model includes ten major reservoirs along with two of Dallas' smaller diversion reservoirs located on the Elm Fork River where Dallas also has water rights. These reservoirs, along with raw water transmission pipelines and pump stations serving the DFW area, and the IPL project are included in the model.

Hydrologic datasets (inflows and evaporation) were developed for each reservoir for a 114-year period beginning January 1907 and ending December 2020. The January 1907 date was selected based on available streamflow records at key USGS streamgages and was just prior to a severe drought that occurred in the region from 1908-1913. The Dallas model can perform yield analyses for all of the reservoirs, optimize system operations, and make statistical lake level projections. The Dallas RiverWare model is a tool used in the development of the 2024 LRWSP and will continue to play a key role as strategies are implemented and incorporated into Dallas operations.

Colorado. Although RiverWare is a trademarked name, a trademark symbol does not appear after every occurrence of the name in this report. http://riverware.org

Figure 1-1. Regional Planning Areas in Texas



Source: Texas Water Development Board. http://www.twdb.texas.gov/publications/shells/RegionalWaterPlanning.pdf

The 2014 LRWSP developed a comprehensive list of potential strategies that could be available to meet Dallas' needs. This effort identified over 300 strategies from previous plans and studies as well as new strategies identified as part of that planning effort. These strategies were evaluated, subject to a multi-tiered fatal flaw / scoring analysis to identify which strategies have the best potential for successful development by Dallas, while meeting future needs and minimizing impacts from project development considering cost, permitting, and implementation challenges. The analysis resulted in six strategies being named recommended to meet the needs of DWU and seven additional strategies being named as alternatives. For the 2024 LRWSP effort, these recommended and alternative strategies were updated for costs, availability, and scored with equity as an additional criterion. A few other new strategies were included by Dallas for additional consideration and are discussed in Section 7. A scoring and ranking analysis was performed to confirm the strategies best suited to meet the future water supply needs of DWU. These strategies were approved by the Dallas City Council and detailed implementation steps were developed to guide Dallas on the path forward to developing these new supplies.

1.5 Coordination with Related Studies

A few related studies were underway during the development of the 2024 Dallas LRWSP providing relevant information and data which was included in the plan. These studies include:

- 2026 Region C RWP,
- Sulphur River Basin Wide Feasibility Study Update, and
- Dallas Water Utilities Water Production Facilities Strategic Plan.

1.6 Coordination with Customer Cities

DWU staff coordinated with their customer cities and inquired about relevant planning data that may be available for use in the 2024 LRWSP. Where applicable and available, this data was included in the development of the 2024 LRWSP.

1.7 Public Involvement

Public involvement during the study period and development of the plan included public presentations, public meetings, and public comment periods at various decision points during the process.

This Page Intentionally Left Blank.

2 Planning and Service Area

The City of Dallas has a long history of water supply planning dating back to the 1950's. Droughts, including the 1950's event, along with rapid population growth highlight the importance of planning to meet growing water demands with dependable water supplies. As the regional water provider for the City of Dallas and a large portion of the surrounding area, DWU has continued planning during the decades since, adapting to increased population and demand. One of the primary steps of the planning process is identifying who is included in the existing service area and projecting where future growth may occur. The 2024 Long Range Water Supply Plan (2024 LRWSP) is the latest edition of water supply plans, providing DWU with a defined path moving forward to meet the needs of a growing region with water supplies for the residents of the City of Dallas and its wholesale customers' needs.

2.1 Existing Service Area

To establish an accurate accounting of the DWU service area for the 2024 LRWSP, the service area is divided into retail and wholesale customers. Retail customers are mainly comprised of residents and businesses within the city of Dallas, while wholesale customers are generally made up of municipalities and water districts located outside of the Dallas city limits. The approach to evaluating the existing service area is the same as the process used to develop the 2014 LRWSP. Table 2-1 provides information on DWU's current retail, wholesale treated, and untreated water customers.

The DWU service area extends beyond the city limits of Dallas to serve customer cities in the counties of Dallas, Collin, Denton, Ellis, Kaufman, and Tarrant. The service area of DWU is the area serviced by its existing customers. The service area is represented in Figure 2-1 through Figure 2-5. Figure 2-1 represents DWU's retail customer service area. Figure 2-2 represents DWU's retail customers within the city limits and its treated water customer cities, listed in Table 2-1, and the area served by those entities. Figure 2-3 represents DWU's untreated water customers, listed in Table 2-1 and the area served by those entities. Figure 2-4 shows the DWU's retail area and the combined treated and untreated service area. Defining the service area as a table in combination with a map showing the area served by the customers, will help alleviate potential ambiguous interpretations of DWU's service area obligations.

Table 2-1. DWU Retail and Wholesale Customers

Customer City	Supply Type	Contract Expiration Date	Approximate Current Demand on Dallas (MGD)[1]
Addison	Treated	1/5/2042	5.1
Balch Springs	Treated	9/10/2045	2.3
Carrollton	Treated	6/28/2043	23.0
Cedar Hill	Treated	9/25/2044	7.0
Cockerell Hill	Treated	2/21/2044	0.5
Combine WSC	Treated	12/13/2035	0.3
Coppell	Treated	11/17/2047	11.0
DFW Airport	Treated	10/07/2045	2.6
Dallas Retail[2]	Treated	NA	246.0
Desoto	Treated	8/23/2043	10.0
Duncanville	Treated	9/29/2044	4.9
Ellis County WCID #1[3]	Treated	8/12/2033	0
Farmers Branch	Treated	7/31/2040	8.2
Flower Mound	Treated	1/20/2047	5.4
Glenn Heights	Treated	2/11/2052	2.5
Grand Prairie	Treated	1/05/2042	25.1
Hutchins	Treated	3/30/2042	1.2
Irving	Treated	6/29/2033	6.4
Lancaster (w/ Lancaster MUD 1)	Treated	11/10/2041	8.7
Wilmer[4]	Treated	N/A	
Lewisville (w/ Denton County FWSD 1-A)	Treated	6/03/2046	10.3
Ovilla	Treated	12/13/2035	0.6
Red Oak	Treated	8/12/2033	1.5
Seagoville	Treated	2/01/2043	1.6
The Colony	Treated	11/04/2040	4.7
		Total	**388.9**

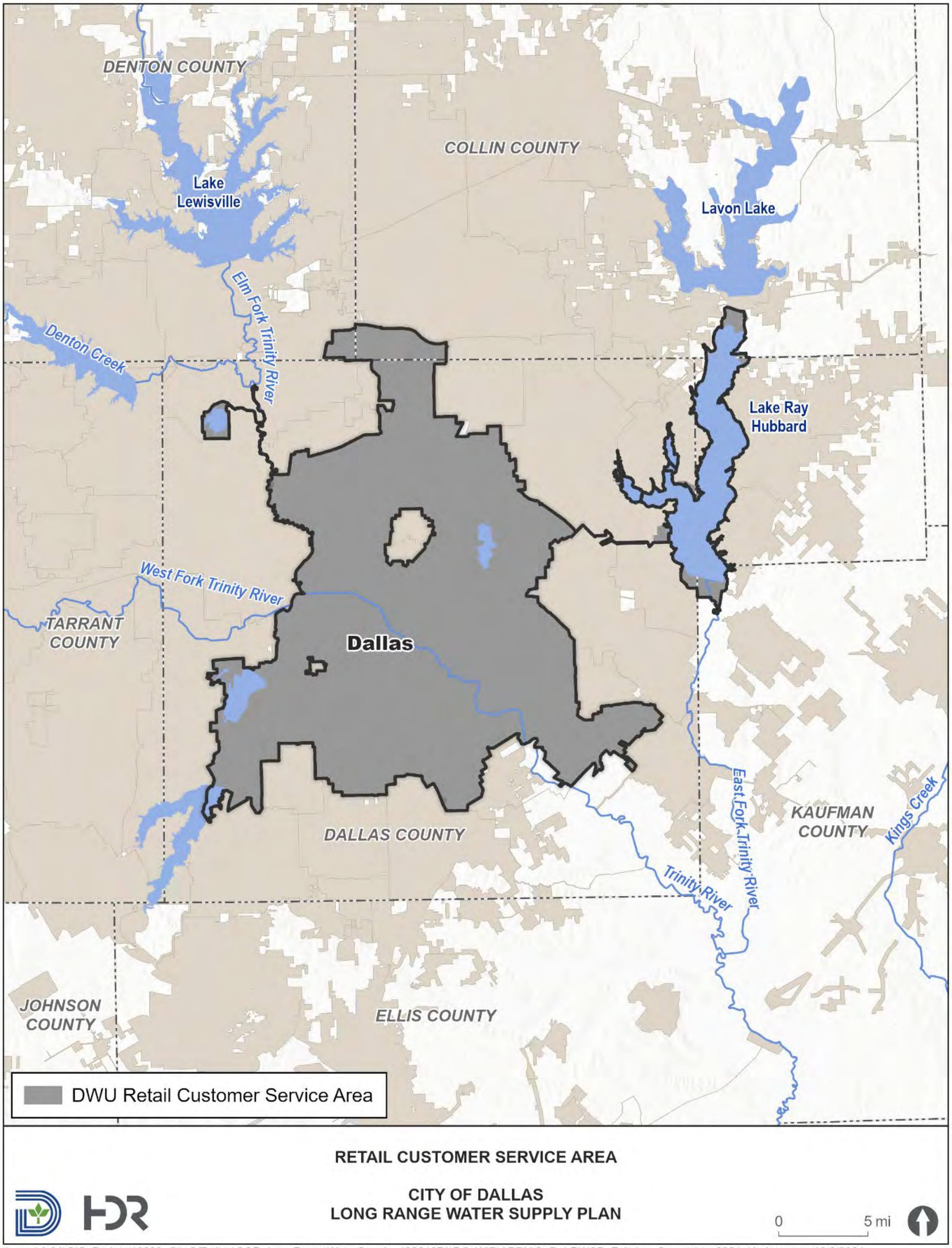
[1] Source – Demand Comparisons – DQ26-26-Jun-2024 – FY 2023

[2] Source – Email communication w/DWU 10-3-24

[3] Contract is current but has no physical connection to the DWU system and is not included in the service area maps

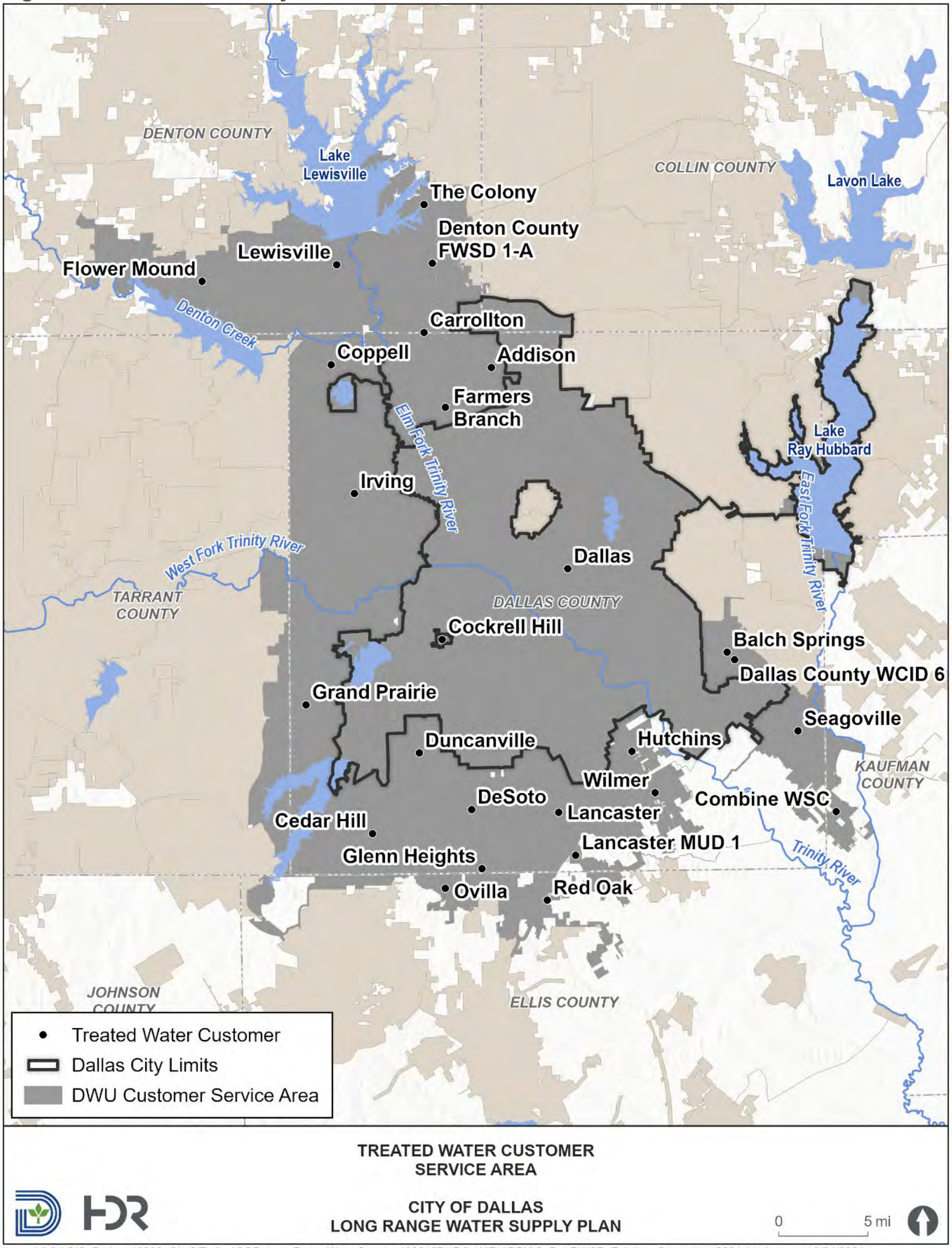
[4] Wilmer receives DWU water through permitted secondary sales by Lancaster. Wilmer is not contracted with DWU

Figure 2-1. DWU Retail Customer Service Area



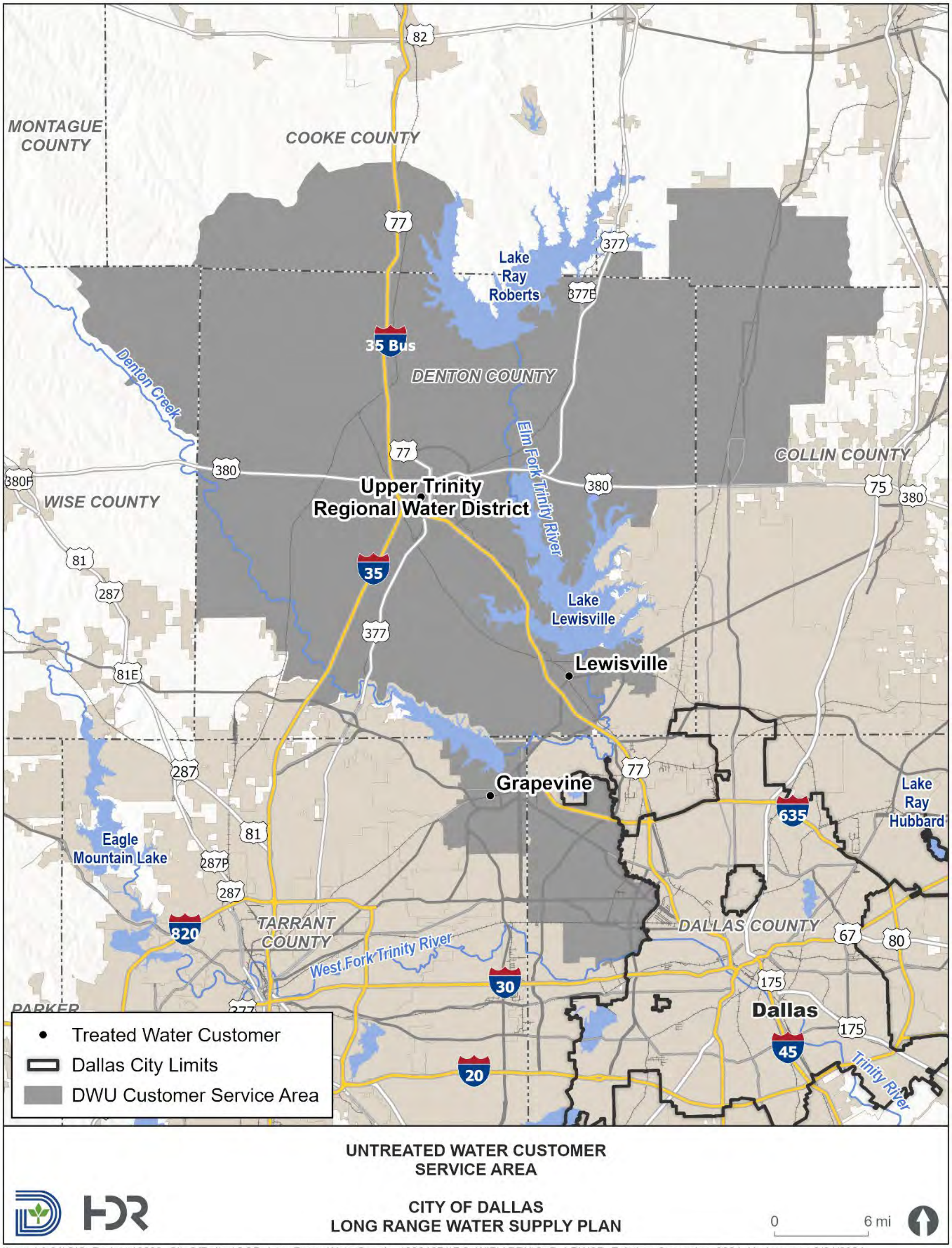
\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 10/3/2024

Figure 2-2. Area Served by DWU and Its Treated Water Customers



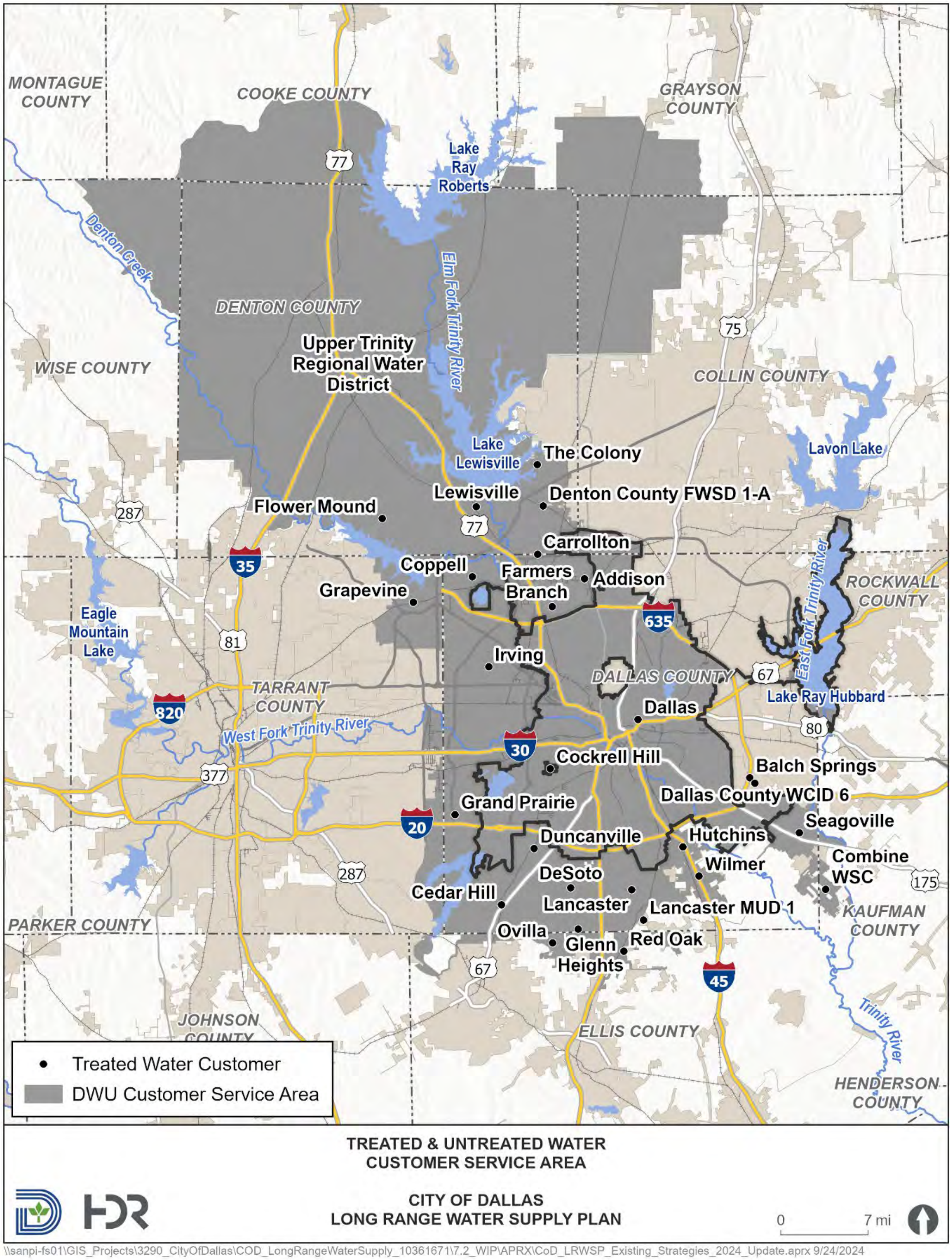
\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 9/24/2024

Figure 2-3. Area Served by DWU and Its Untreated Water Customers



\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 9/24/2024

Figure 2-4. Combined Service Area for DWU and Its Treated and Untreated Water Customers



2.2 Recommended Planning Area

The City intends to provide services to existing customers and is not actively pursuing new communities for provision of water. As such, the service area studied and recommended strategies reflect meeting the needs of existing customers. Although the City of Dallas is not actively planning to meet the needs of other entities, there have been several entities request service. These entities are discussed in Section 2.2.1.

2.2.1 Service Requests

The City of Dallas since the 2014 LRWSP has been approached formally and informally by incorporated and unincorporated areas adjacent to or near the DWU service area. These areas include the City of Sunnyvale, the City of Heath, City of McClendon-Chisolm, Rocket Special Utility District (SUD), the unincorporated area of Sand Branch. During the development of the 2024 LRWSP the City of Rowlett officially requested treated water service from DWU. This request, at the time of the writing of this report was being evaluated by DWU staff. DWU does not currently serve these customers and has no obligation to serve them in the future.

- City of Sunnyvale - is a current customer of North Texas Municipal Water District (NTMWD), DWU's Eastside WTP is located in Sunnyvale.
- City of Heath – is an indirect customer of NTMWD through the City of Rockwall and adjacent to the City of Dallas's Lake Ray Hubbard.
- City of McClendon-Chisolm – is an indirect customer of NTMWD through the City of Rockwall and the RCH and Blackland Water Supply Corporations, and the Cities of Forney and Tarrell through the High Point Special Utility District.
- Rocket SUD – is located to the south of the City of Dallas in Ellis County.
- Sand Branch – is an unincorporated area southeast of the City of Dallas adjacent to the City of Seagoville and does not have water infrastructure.
- City of Rowlett – Contract with NTMWD recently expired and is adjacent to Lake Ray Hubbard.

2.3 Adjacent Areas Served by Other Agencies

Part of understanding DWU's service area is to understand what areas are served by other Metroplex area water providers. There are four additional large wholesale providers that combined with DWU, serve a majority of DFW metroplex. Figure 2-5 is a regional map that shows how the service areas and current customers of these wholesale water providers border DWU's service area.

2.3.1 North Texas Municipal Water District (NTMWD)

NTMWD supplies treated water to 13 member cities and 34 customers cities and utilities in suburban communities located north and east of the City of Dallas. NTMWD obtains raw water from Lake Lavon, Lake Texoma, Chapman Lake, all of which are owned and operated by the Corps of Engineers. Bois D'Arc Lake is the newest water supply source in Fannin County which is owned and operated by NTMWD. NTMWD also has a permit to reuse treated wastewater effluent from its Wilson Creek Wastewater Treatment Plant which discharges into Lake Lavon and diversions from its East Fork Water Supply Project which includes NTWMD discharges currently being passed through Lake Ray Hubbard. These supplies are blended with other supplies in Lake Lavon, including supplies from Lake Tawakoni, Lake Fork, and Lake Bonham.

2.3.2 Tarrant Regional Water District (TRWD)

TRWD supplies raw water to 30 wholesale customers in Tarrant and ten other surrounding counties. The District also has commitments to supply water through the Trinity River Authority to users in Ellis County. TRWD owns and operates Lake Bridgeport, Eagle Mountain Lake, Cedar Creek Reservoir, and Richland-Chambers Reservoir. The District's water supply system also includes Lake Arlington (owned by the City of Arlington), Lake Worth (owned by the City of Fort Worth), and Benbrook Lake (owned by the Corps of Engineers, with TRWD holding water rights), a major reuse project, and a substantial water transmission system.

2.3.3 Trinity River Authority (TRA)

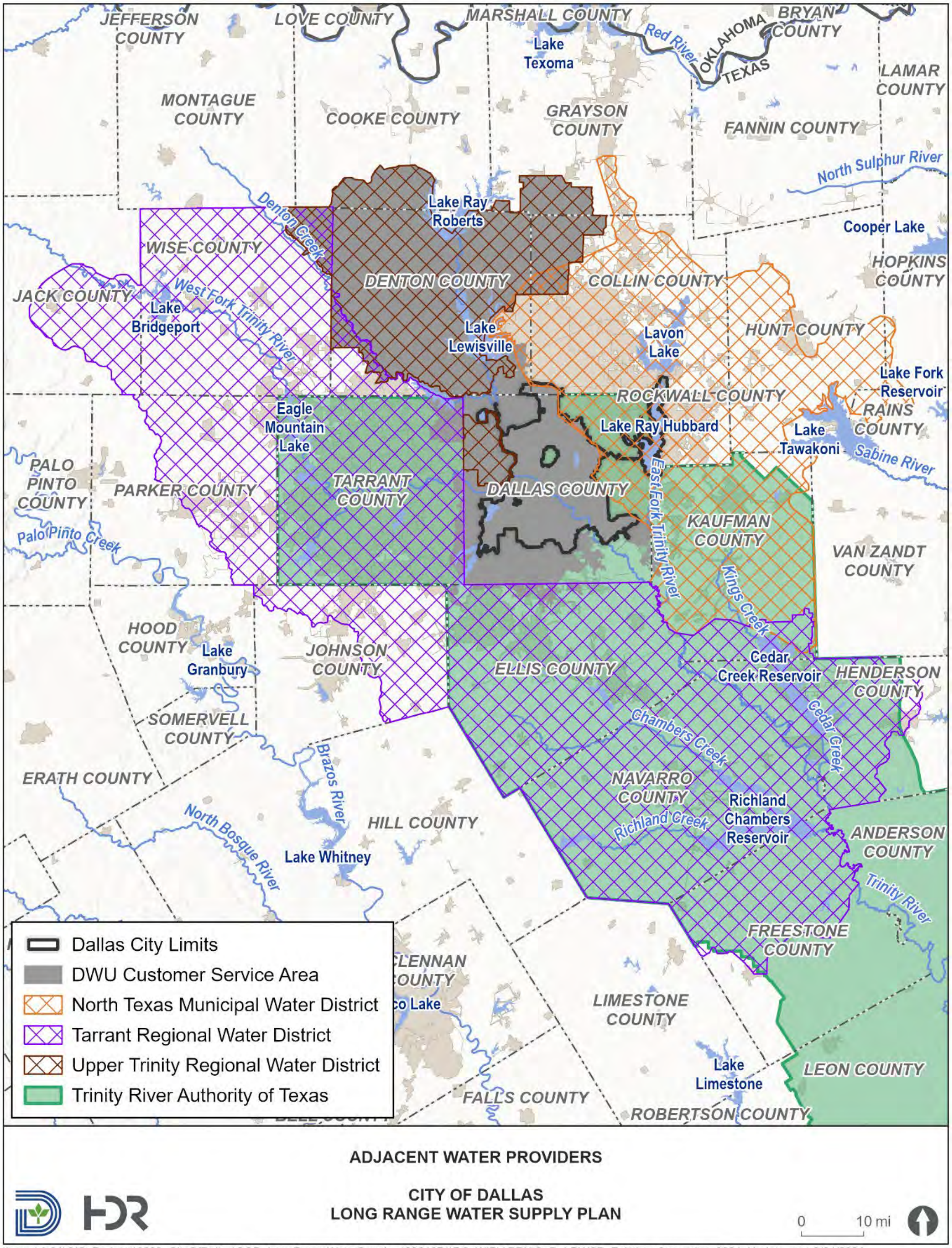
TRA holds water rights in Joe Pool Lake (and has contracts to supply water to the Cities of Midlothian, Duncanville, Cedar Hill, and Grand Prairie, but does not currently have the infrastructure to do so), Navarro Mills Lake (serves City of Corsicana), and Bardwell Lake (serves Cities of Ennis and Waxahachie). All of these lakes are owned and operated by the Corps of Engineers. TRA sells raw water to Luminant for use in the Big Brown Steam Electric Station on Lake Fairfield. This water is diverted from the Trinity River under water rights held by TRA in Lake Livingston. TRA has a regional treated water system in northeast Tarrant County, which treats raw water delivered by the Tarrant Regional Water District system through Lake Arlington with TRA selling treated water to the Cities of Bedford, Colleyville, Euless, Grapevine and North Richland Hills. TRA also has a commitment to sell raw water provided by the TRWD to water suppliers in Ellis County and is currently selling water to some of these entities.

2.3.4 Upper Trinity Regional Water District (UTRWD)

UTRWD operates a regional water supply system located primarily in Denton County but has grown into the surrounding counties, a rapidly growing area. UTRWD has a contract with the City of Commerce to divert raw water from Chapman Lake in the Sulphur River Basin and operates treatment facilities with a capacity of about 90 MGD. UTRWD cooperates with the City of Irving to deliver Lake Chapman water to Lewisville Lake.

UTRWD also has contracts to buy raw water from the Cities of Dallas and Denton and has an indirect reuse permit to reuse a portion of the water discharged to Lake Lewisville.

Figure 2-5. Service Area of DWU and Customer Cities with adjacent Water Providers



\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 9/24/2024

3 Population Projections

The 2024 LRWSP's population projections for City of Dallas retail customers and DWU customer cities are provided in this section. The customer city projections are consistent with population projections for the 2026 Region C RWP, with a few exceptions for customer cities with current demand exceeding the Region C RWP projections. City of Dallas retail population projections have been developed using in-depth research and analysis performed by the HDR team. HDR included Maddaus Water Management (MWM) on our team to engage their expertise in population, demand and conservation evaluation. In addition to current projections, this section provides comparisons to the 2014 LRWSP and 2026 Region C RWP population projections.

3.1 Population Projection Methodology

MWM created a population projection for City of Dallas retail customers for the 2024 LRWSP and refined the forecast with input from DWU and HDR. Growth rates for MWM's projection were sourced from Texas Demographic Center (TXDC) data and applied to the current baseline population to simulate growth. The population growth was allocated to housing types and distributed to available residencies. Housing type distributions and available residency data were provided by the American Communities Survey (ACS), Dallas Planning and Urban Design (DPUD), and the North Central Texas Council of Governments (NCTCOG).To further refine the DWU retail population projections, MWM used geospatial data from DWU, the U.S. Census Bureau, and NCTCOG to assign projected population growth to DWU's pressure zones by census tract and land use. The projected population of all census tracts lying within each pressure zone were added together to determine the population of the respective pressure zone. This analysis will allow DWU to plan for spatial variability in the population growth of its service area. Past planning cycles relied on TWDB mapping of population within DWU's service area and did not capture the rapid growth in some pressure zones and over-predicted growth in others.

Draft projections and methodology were presented to DWU and others from the City of Dallas, on June 8, 2023, at Dallas City Hall. Input from that meeting was incorporated by MWM into the analysis to produce population projections which were provided to DWU in July of 2023. In November 2023, the TXDC produced updated municipal population estimates that the HDR team used to update their modeling efforts. The November 2023 TXDC municipal population estimates necessitated a revision to Dallas' July 2023 population projections due to the increase in population that they reported. The increase from 2022 TXDC data and the November 2023 TXDC data is likely due to a rebound in municipal population after the COVID19 pandemic. The revised projections were ultimately finalized in March 2024.

Population projections for DWU's customer cities are directly sourced from TWDB-adopted population projections for the 2026 RWP planning cycle. The TWDB population projections were adopted November 9, 2023, after the Region C Water Planning Group provided input on the May 2023 draft projections released by the TWDB. The iterative TWDB process allowed DWU to solicit input from its customer cities and provide feedback to Region C with local knowledge of population growth in the area.

3.2 Results of Population Projection for City of Dallas

Population projections for City of Dallas retail customers and DWU customer cities are provided by decade in Figure 3-1 and Table 3-1. The total population of individuals living in areas potentially served by DWU in 2030 is projected at just under 3 million, with nearly 1.4 million individuals dwelling within the City of Dallas and close to 1.5 million dwelling in DWU customer cities. Note this includes the total population of the customer cities, not just the population in those cities that are receiving water from DWU. The combined population of the DWU retail customers and DWU customer cities is projected to increase by approximately 40 percent between the year 2030 and the year 2080. DWU retail customer population is projected to increase to over 2.1 million in 2080, and customer city population is projected to increase to approximately 1.9 million in 2080. This corresponds to a nearly 54 percent population growth for City of Dallas retail customers and almost 27 percent growth for DWU customer cities over the fifty-year projection period.

City of Dallas retail customer population growth is distributed by pressure zone in Table 3-2. A map of DWU pressure zones can be seen in Figure 3-2. Over the projection time period of 2030 to 2080, the Central Low pressure zone experiences the largest over-all growth at just over 225,000 individuals. North High and South High see the second and third largest projected growths with roughly 181,000 and 124,000 respectively. Of the major pressure zones, Central Low and Cypress Waters tie for the largest percent growth at 76 percent. Lovers Lane Intermediate is a close third at just under 75 percent growth during the projection period.

Figure 3-1. Population Projections for City of Dallas and DWU Customer Cities

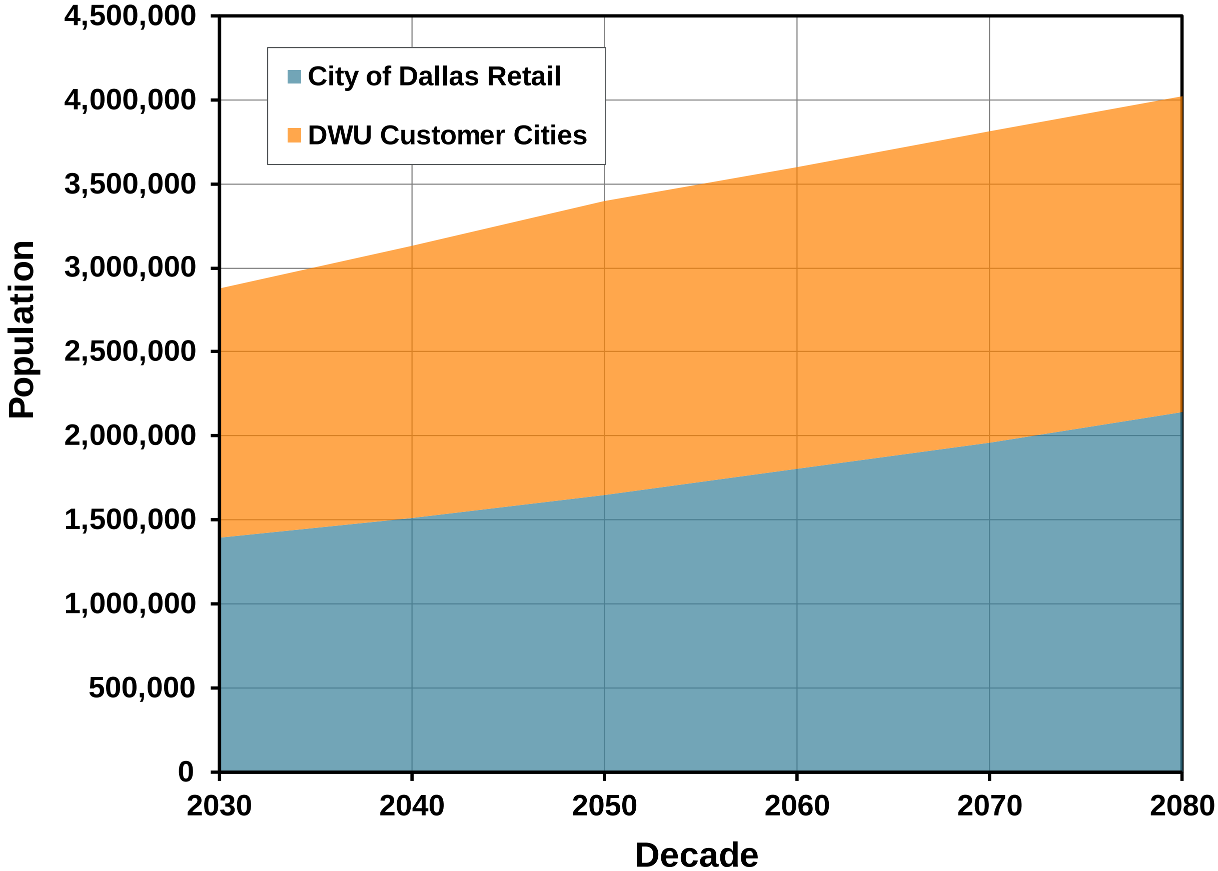


Table 3-1. Population Projections for City of Dallas and DWU Customer Cities

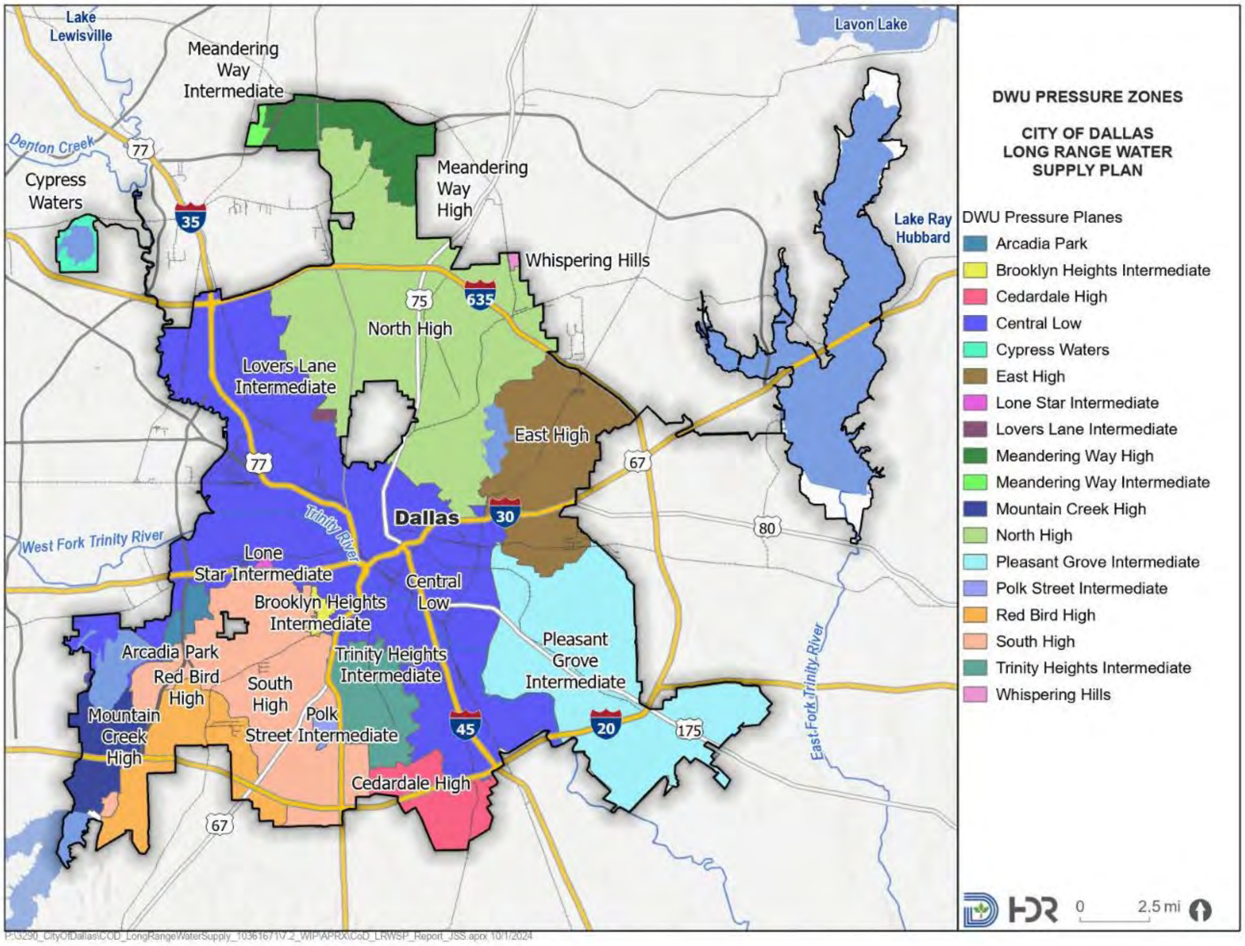
Entity	2030	2040	2050	2060	2070	2080
City of Dallas	1,393,479	1,508,053	1,647,570	1,804,405	1,959,091	2,142,389
Customer Cities+	1,482,461	1,623,351	1,747,982	1,796,745	1,851,489	1,879,771
Total Population	**2,875,940**	**3,131,404**	**3,395,552**	**3,601,150**	**3,810,580**	**4,022,160**

+The total Customer Cities population does not reflect the DWU portion served, and instead, reflects the full population approved by the TWDB on November 9, 2023.

Table 3-2. Population Projections for City of Dallas Retail by Pressure Zone

Dallas Pressure Zones	2030	2040	2050	2060	2070	2080
Arcadia Park	8,751	9,323	9,945	10,512	11,037	11,683
Brooklyn Heights Intermediate	4,529	4,911	5,540	6,196	6,770	7,408
Cedardale High	7,483	7,924	8,444	9,105	9,723	10,472
Central Low	296,123	326,330	364,196	410,473	460,692	521,129
Cypress Waters	1,474	1,633	1,815	2,052	2,285	2,587
East High	125,417	134,926	145,830	156,965	167,199	179,256
Lone Star Intermediate	0	6	21	64	93	134
Lovers Lane Intermediate	1,851	2,091	2,356	2,635	2,883	3,238
Meandering Way High	76,747	83,958	92,200	101,880	114,492	130,042
Meandering Way Intermediate	6,378	7,064	7,591	8,176	8,723	9,346
Mountain Creek High	3,046	3,259	3,605	4,030	4,536	5,201
North High	322,559	352,418	388,325	427,943	462,987	503,957
Pleasant Grove Intermediate	133,194	141,647	152,247	164,149	175,232	188,323
Polk Street Intermediate	4,012	4,233	4,420	4,598	4,767	4,966
Red Bird High	36,066	38,694	42,031	45,756	48,758	52,258
South High	315,882	335,556	360,768	387,084	411,847	440,311
Trinity Heights Intermediate	47,800	51,754	55,746	60,156	64,317	69,199
Whispering Hills	2,167	2,326	2,490	2,631	2,750	2,879
Total DWU Retail	**1,393,479**	**1,508,053**	**1,647,570**	**1,804,405**	**1,959,091**	**2,142,389**

Figure 3-2. City of Dallas Pressure Zones



3.3 Results of Population Projection for Customer Cities

DWU customer city population projections are disaggregated in Table 3-3 and Table 3-4. The former (Table 3-3) provides population projections for cities purchasing treated water from DWU; the latter (Table 3-4) provides projections for cities purchasing untreated water. Table 3-5 compares the projected populations of DWU customer cities that purchase treated and untreated water. It should be noted that the full population of each customer city is included in these figures regardless of whether or not DWU is their sole source of water. Irving and Grand Prairie remain the largest customer cities throughout the projection period with projected 2080 populations of approximately 304,000 and 300,000 respectively. Grand Prairie is projected to experience the largest growth with just under 77,000 individuals and Ovilla is projected to experience the largest percent growth at approximately 147 percent over the fifty-year projection period. The Upper Trinity Regional Water District (UTRWD) is the largest untreated water customer. In UTRWD's contract with Dallas, UTRWD provides service to Argyle WSC, Corinth, Flower Mound, Highland Village, and Lake Cities Municipal Utility Authority utilizing water supplies from Dallas. Note that Flower Mound is accounted for in the treated water customer cities and is therefore excluded from the population projections for customer cities purchasing DWU water from UTWRD.

Table 3-3. Population Projections for DWU Customer Cities: Treated Water

Entity	2030	2040	2050	2060	2070	2080
Addison	20,465	23,069	24,456	25,276	26,179	27,173
Balch Springs	28,412	30,394	33,234	36,214	40,018	42,000
Carrollton	141,268	149,561	158,341	167,636	177,477	178,153
Cedar Hill	53,645	58,553	63,911	69,070	74,646	80,672
Cockrell Hill	3,610	3,380	3,255	3,176	3,089	2,993
Combine WSC	3,604	4,094	4,678	5,309	6,009	6,784
Coppell	43,777	43,632	43,757	43,857	44,000	44,000
DFW Airport	-	-	-	-	-	-
Desoto	59,901	63,934	66,069	67,304	68,664	70,162
Duncanville	43,672	45,939	47,157	47,307	47,307	47,307
Farmers Branch	36,454	39,795	41,570	42,609	43,754	45,014
Flower Mound	95,690	119,876	145,420	145,481	145,555	145,555
Glenn Heights	22,178	25,909	29,228	32,297	35,668	39,377
Grand Prairie	223,551	250,447	281,412	289,414	300,401	300,401
Hutchins	8,346	9,300	9,808	10,107	10,436	10,799
Irving	285,073	302,931	303,163	303,400	303,641	303,641
Lancaster & Lancaster MUD 1	46,953	50,263	52,017	53,034	54,154	55,387
Wilmer	5,902	6,672	7,081	7,324	7,591	7,885
Lewisville & Denton County FWSD 1-A+	138,788	147,715	157,909	160,047	163,162	163,162
Ovilla	5,438	6,827	8,337	9,871	11,556	13,411
Red Oak	12,039	15,009	18,237	21,502	25,093	29,044
Seagoville	20,875	22,892	23,964	24,593	25,285	26,047
The Colony	51,496	60,502	67,600	67,600	67,600	67,600
Treated Water Totals	**1,351,137**	**1,480,694**	**1,590,604**	**1,632,428**	**1,681,285**	**1,706,567**

+ Denton County FWSD 1-A has been absorbed by Lewisville

Table 3-4. Population Projections for DWU Customer Cities: Untreated Water

Entity	2030	2040	2050	2060	2070	2080
Grapevine	54,037	54,037	54,037	54,037	54,037	54,037
Lewisville (45% Untreated)	Population included in Table 3-3					
UTRWD[1]	77,287	88,620	103,341	110,280	116,167	119,167
Irrigation[2]	-	-	-	-	-	-
Untreated Water Totals	**131,324**	**142,657**	**157,378**	**164,317**	**170,204**	**173,204**

[1] Includes Argyle WSC, Corinth, Highland Village, Lake Cities Municipal Utility Authority; other entities serviced by UTRWD are either not receiving DWU water or are accounted for in the treated water customer cities

[2] Includes Carrollton-Farmers Branch ISD, Carrollton-Indian Creek Golf Course, Garland-Firewheel Golf Course, Hickory Creek-Arrowhead Park, Highland Village-Double Tree Ranch, Rowlett-Waterview Golf Course.

Table 3-5. Combined Population Projections for DWU Customer Cities

Entity	2030	2040	2050	2060	2070	2080
Treated Water Totals	1,351,137	1,480,694	1,590,604	1,632,428	1,681,285	1,706,567
Untreated Water Totals	131,324	142,657	157,378	164,317	170,204	173,204
Combined Customer City Totals	**1,482,461**	**1,623,351**	**1,747,982**	**1,796,745**	**1,851,489**	**1,879,771**

3.4 Comparison of Population Projections

A direct comparison of the 2024 LRWSP population projections with the 2014 LRWSP and TWDB-adopted population projection data for the 2026 Region C RWP is provided in Table 3-6 and Figure 3-3. The populations of customer cities purchasing both treated and untreated water were included in all three population projections for a complete comparison. It should be noted that for all three projections, the full population of each customer city is included in these figures regardless of whether or not DWU is its sole source of water.

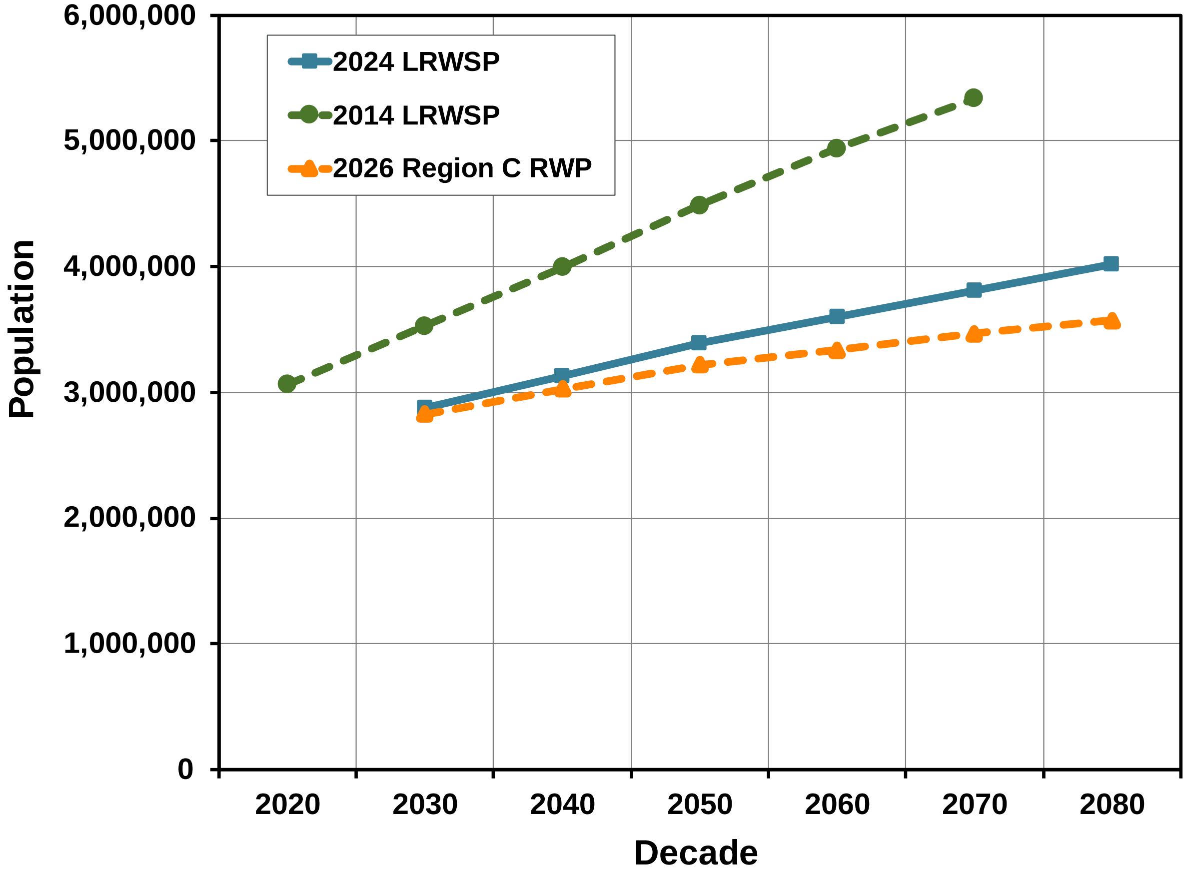
The 2024 LRWSP population projections are lower than those in the 2014 LRWSP but are slightly higher than the 2026 Region C RWP population projections. In the year 2070, the 2024 LRWSP projects there will be approximately 1.5 million fewer individuals living in the DWU service area, whether served by DWU or not, than the 2014 LRWSP projected. This corresponds to a 40 percent higher population projected by the 2014 LRWSP with respect to the 2024 LRWSP. The 2026 Region C RWP population projection for 2070 was approximately 345,000 individuals less than the 2024 LRWSP, corresponding to a difference of just over 9 percent with respect to the 2024 LRWSP. In the years between 2030 and 2070, population growth rates for the 2024 LRWSP average close to 23,000 individuals per year or approximately 0.7 percent per year. The 2026 Region C RWP data projects a growth rate of approximately 17,000 individuals per year or approximately 0.5 percent per year. Similarly to overall population estimates, the 2014 LRWSP growth rate was higher at roughly 45,000 individuals per year, or 1.0 percent per year. Differences in 2024 LRWSP projections and 2026 Region C projections can be attributed to the in-depth research and analysis performed by the HDR team which reflects a higher review resolution of potential growth for the city. Differences between the 2024 LRWSP and the 2014 LRWSP projections largely reflect the differences in how each plan accounts for UTRWD's member city populations. The 2014 plan includes all of UTRWD, while the 2024 plan accounts for cities contracted with UTRWD to receive DWU water. The 2024 and 2014 LRWSPs also differ in methodology due to the in-depth population modeling done for the DWU retail customers by the HDR team including MWM. Finally, population growth trends may also be the source of population projection differences.

Table 3-6. Population Projections from Other Studies

Plan	2030	2040	2050	2060	2070	2080
2014 LRWSP+	3,527,191	3,995,923	4,488,158	4,941,083	5,335,956	-
2026 Region C RWP+	2,824,750	3,027,454	3,218,679	3,337,295	3,465,943	3,572,073
2024 LRWSP+	2,875,940	3,131,404	3,395,552	3,601,150	3,810,580	4,022,160

+The total Customer Cities population does not reflect the DWU portion served, and instead, reflects the full population approved by the TWDB on November 9, 2023.

Figure 3-3 Comparison of Population Projections for City of Dallas and Customer Cities



This Page Intentionally Left Blank.

4 Water Demands

This section describes the development of the updated water demand projections for the 2024 LRWSP with comparisons to those in the 2014 LRWSP and the 2026 Region C RWP. The 2024 LRWSP water demand projections consist of City of Dallas retail demands, DWU Customer Cities treated demands, and DWU Customer Cities untreated demands. The collective demands of City of Dallas Retail and DWU Customer Cities are referred to as the DWU System demands throughout this report.

The development of the City of Dallas Retail and DWU Customer Cities water demand projections are described in separate sections below. Alternative approaches were taken in the development of these projections. The City of Dallas Retail water demand projections were developed through use of the DSS model with the input of multiple, detailed criteria. The DWU Customer Cities water demand projections were developed using the TWDB Region C water user group (WUG) demand projections or through use of 2023 water sales data and gallon per capita per day (GPCD) calculations.

4.1 Basis of City of Dallas Retail Water Demand Projections

The City of Dallas Retail water demand projections were developed by Maddaus Water Management (MWM) through use of the Decision Support System (DSS) Model to develop demand forecasts from the bottom-up with consideration of detailed criteria and historical data to estimate future water demands. Estimated plumbing code savings were also incorporated into the modeling approach.

The data topics collected for use in the development of the water demand projection included:

- General information – planning documents, abnormal years
- Historical data – customer class descriptions, water production and consumption, cost of water.
- Demographic and weather data – unemployment rates, jobs, historical weather

The production and consumption data were used to develop a historical baseline demand profile to provide a starting point for projection efforts. The consumption data was broken down into DWU customer categories including single family residential, apartments, industrial, municipal, commercial, and wholesale. The population projections described in Section 3 served as the basis for individual customer water use categories and helped characterize water usage for each customer category in terms of GPCD. City of Dallas Retail water use was further broken down into indoor and outdoor components to help determine historical use patterns.

Demand growth factors were then applied to the City of Dallas Retail historical baseline demand estimate that resulted from the data collection and customer category breakdown. Growth factors included retail total population, retail single family population, retail apartment population, retail commercial jobs, retail group quarters/mobile home/boats population, and commercial account use. Through the application of City of Dallas-specific growth factors to the historical baseline demand, a normalized demand with plumbing code savings was developed for the City of Dallas Retail average day demands.

Non-municipal water usage, for example, industrial water use, is not a separate projection and has been included in the City of Dallas Retail average day demands based on historical use and DWU customer category evaluation.

The City of Dallas Retail water demand projection by pressure zone was generated through three pressure zone-based ratios including residential, non-residential, and non-revenue water.

4.2 Basis of DWU Customer Cities Water Demand Projections

The development of the 2024 LRWSP water demands coincides with the development of the TWDB Region C 2026 Regional Water Plan board adopted water demand projections, released November 9th, 2023. The water demands for DWU Customer Cities were sourced directly from TWDB Region C's WUG projections or used as a starting point to develop demands that better reflect the actual demands that DWU is seeing from certain customer cities.

4.2.1 Customer Cities Demand Projections from the TWDB

The TWDB water demand projections were developed from the permanent residential population projections and a per capita water use comprised of residential, commercial, and institutional water use for each WUG. The following customer cities utilized TWDB water demand projections: Addison, Balch Springs, Cedar Hill, Combine WSC, DFW Airport, Duncanville, Farmers Branch, Flower Mound, Hutchins, Irving, Wilmer, Lewisville, Ovilla, Seagoville, The Colony, Grapevine, and Upper Trinity Regional Water District (UTRWD).

The GPCD developed for the TWDB WUG water demand projections represents historical 'dry year' water use. The use of historical 'dry year' data indicates that the demands provided are average drought day demands and reflect water use during "dry" conditions. The GPCD accounted for plumbing code savings that are anticipated to result from federal and state laws mandating the efficiency of all new appliances and fixtures sold in retail stores. Implementation of plumbing codes results in passive water efficiency savings from residential toilets, clothes washers, showerheads, and commercial toilets and urinals. Useful life of fixtures/appliances were determined, and replacement rates based on the number of people within a WUG in each decade were developed by the

TWDB. Plumbing code savings were projected for each type of fixture/appliance based on WUG population projections and combined to determine the total projected plumbing code savings for each WUG. The plumbing code savings was subtracted from each WUG GPCD. The TWDB projected GPCD values for the DWU Customer Cities are shown in Table 4-1.

The total water demand for each customer city was calculated from the TWDB population projections and WUG-specific GPCD. For customer cities with multiple sources of water, a portion of its total demand was allocated to the DWU system. The allocation percentage was determined based on an average of two years of DWU Customer Cities water sales totals (FY 19-20 and FY 20-21) compared to the TWDB demands from 2020. The percentage of Customer Cities demands served by the DWU system was held constant over the entire projection period. The DWU percent supply allocations for DWU Customer Cities with multiple sources of water is shown in Table 4-7.

DWU is contracted to treat Irving's entire water demand, however, only 37% of Irving's treated water demand is provided by DWU from Dallas water supply sources. The remaining 63% of Irving's demand comes from Irving's water supply source, Jim Chapman Lake, and is subsequently treated by DWU. The water demand projection for Irving, as shown in Table 4-4 and Table 4-7, includes only the 37% of Irving's total water demand provided by DWU through Dallas water supply sources. Irving has other water supply sources and DWU is not contracted to serve Irving's entire projected water demand through Dallas water supply sources. The water demand treated by DWU not included in the total water demand projection is considered in Chapter 8 with respect to treated water demands and water production facility capacities.

The DWU System provides untreated water supplies to Grapevine, Lewisville, UTRWD, and various non-municipal customers included under irrigation. These Customer Cities untreated water demands are based on the TWDB water demand projections and the DWU Customer Cities 2023 water sales totals to determine the allocation percentage. The Customer Cities contracted to be served through UTRWD are Argyle WSC, Denton County FWSD 1-A, Corinth, Flower Mound, Highland Village, Lake Cities Municipal Utility Authority, and 10 MGD of additional contractual demand. However, Denton County FWSD 1-A's entire demand has been included in Lewisville's demand and therefore was not included in the UTRWD demand shown below. Additionally, since DWU already serves 33% of Flower Mound's demand directly, as accounted for in Table 4-4, only the remaining 67% of Flower Mound's demand was included in the UTRWD demand. It should be noted that the contracted pass-through water supply volume from Lake Chapman is not included in the UTRWD demand shown, as this is not a water demand served by DWU's system. The projected irrigation demands are based on historical actual water sales totals. The DWU Customer Cities untreated water demands are shown in Table 4-5.

4.2.2 Alternative Customer Cities Demand Projections Development

While it was intended to use the TWDB water demand projections for all DWU Customer Cities, it was determined that the projections for some DWU Customer Cities would not be sufficient for projecting future drought demands. Comparison of the 2023 customer cities water sales data and the TWDB demand projections showed some customer cities already exceeding, or anticipated to exceed, the projected 2030 demands developed by the TWDB before 2030. This occurs when actual growth and demands are outpacing projections. To address the outpacing, a new GPCD based on the 2023 customer cities water sales data and the January 1st, 2023, Texas Demographic Center (TDC) population estimate was developed for Carrollton, Cockrell Hill, Coppell, DeSoto, Glenn Heights, Grand Prairie, and Lancaster. The January 1st, 2023, TDC estimate is the same population dataset that was used in the development of the City of Dallas Retail population and demand projections. Utilization of actual demand data and the most recent TDC population estimate produced a GPCD for these customer cities that more closely resembles the demand that the DWU System anticipates serving.

The GPCD calculation used customer cities 2023 water sales data recorded by DWU to raise the demand projections to be greater than the actual billed amount. Plumbing code saving rates as developed by the TWDB were applied to the customer cities GPCD each decade after the 2030 projections. The resulting GPCD values for these seven customer cities were multiplied by the respective TWDB population projections adopted November 9, 2023. These calculations produced average day demands that exceed 2023 actual water sales volumes and reasonably reflect demand trends and the TWDB population projections.

Red Oak is also experiencing outpacing, however, the GPCD adjustment did not provide a sufficient demand increase since Red Oak's service area and city boundaries do not align. To develop an appropriate demand projection for Red Oak, the 2023 water sales volume was multiplied by the decadal percent increase of the original TWDB demand projections. By using this process, Red Oak's GPCD is more than 10 GPCD higher than the GPCD originally developed by the TWDB, while still increasing at the same rate of growth as projected by the TWDB as average day demands.

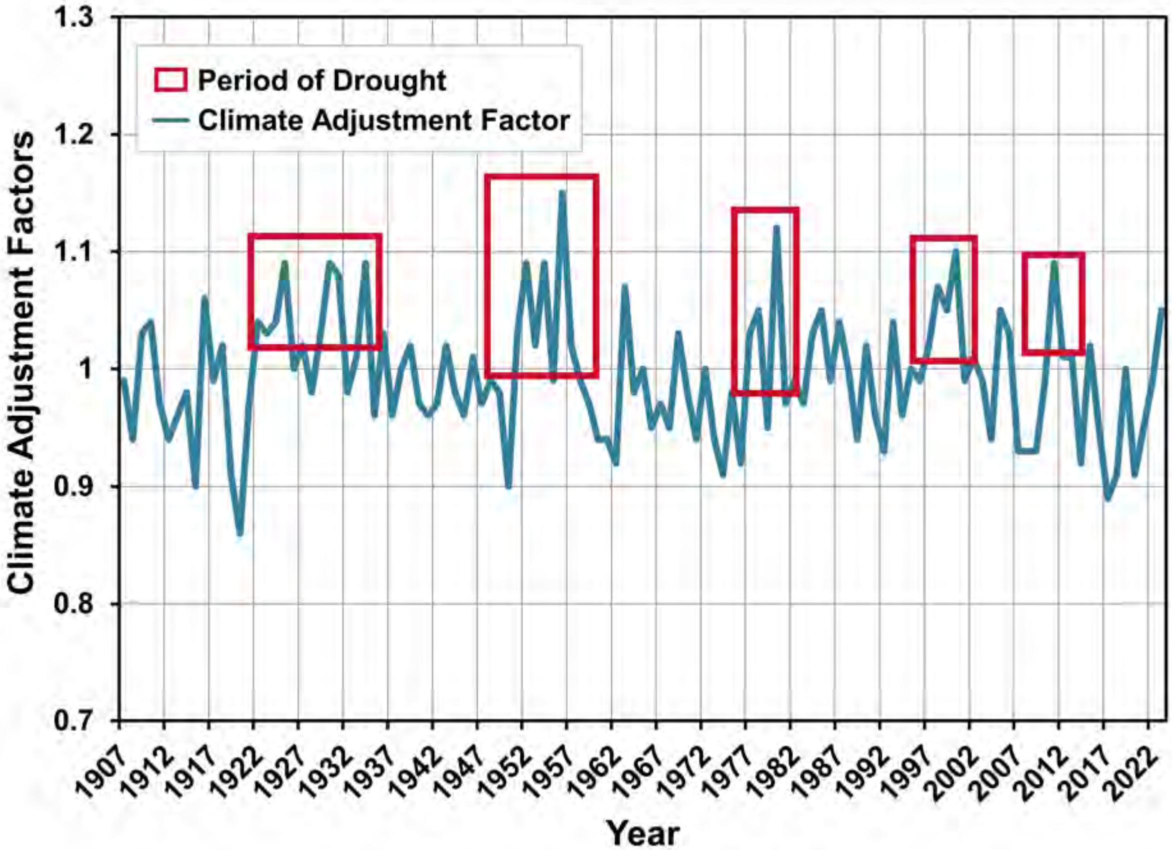
4.3 Drought Adjustment Factor

It is DWU's goal to identify and implement sufficient supply to meet the drought demands of its customers, therefore, a drought adjustment factor was applied to average day demands. The drought adjustment factor is derived from the climate adjustment factors contained in the Dallas RiverWare Model. A constant drought adjustment factor was applied to average day demands to reflect how those demands could be impacted due to extended drought periods.

The drought adjustment factor was only applied to average day demand projections. That includes the City of Dallas Retail water demand projections, and the eight aforementioned customer cities demands that were developed from the 2023 actual billed demands. The drought adjustment factor was not applied to the remaining customer cities demands that use the TWDB demand projections because those demands were developed using ‘dry year’ GPCD water use data, and therefore are already representative of drought demands.

The climate adjustment factors were originally developed in 2010 during the development of the Dallas RiverWare Model by performing an analysis of historical climate data and use patterns from 1907 to 2007. The analysis resulted in developing a regression equation that utilizes historic climate data to develop an adjustment factor which can be applied to average demands to represent “wet” or “dry” conditions and the resulting impact to demands. These factors were updated using the regression equations and included in the LRWSP evaluation for 2008 through 2023. The RiverWare Model incorporates detrended seasonal demands compared against several climate data which included average summer temperature, average max summer temperature, average minimum temperature, total summer precipitation, minimum summer Palmer Drought Severity Index, lawn watering needs, and ratio of average summer temperature to total summer precipitation with the precipitation and temperature ratio chosen as the primary factors. These factors were analyzed to determine the impacts of climate variability to seasonal demands. These annual factors ranged from 0.86 to 1.15 with an average of 0.994 and median of 0.99. By utilizing the climate adjustment factors contained in the RiverWare Model, the fluctuations in demands during extended drought can be calculated to show increases of up to 15%. Utilizing an increase of up to 15% during extended droughts represents a reasonable approach to addressing a worst-case demand scenario. This worst-case scenario ties back to the 1950’s drought of record, with 1956 being the worst drought year. As shown in Figure 4-1, the impacts to demand during several historical drought events ranges up to 15%, based on severity.

Figure 4-1. Climate Adjustment Factors Time Series with Periods of Droughts



To verify the reasonableness of the 15% increase for drought years, a review of climate conditions and production was performed for the last 10 years. Production was very consistent from 2014 through 2021 at an average of 372 MGD, production in 2021 was 373 MGD just above average. However, in 2022 and 2023 production increased significantly over the average from 2014-2021. Increases were 11.6% from 2021 to 2022 and 13.5% from 2021 to 2023. Production was influenced by above normal summer temperatures and lower than normal rainfall totals. Outside of the 10.68" of rainfall in late August 2022, the monthly summer rainfall totals were below average and higher in average monthly temperatures with single day spikes of 110 degrees in August and September 2023. With the increase in climate variability, similar years could occur more often moving forward. Based on this approach, a drought adjustment factor of 15% was applied to average day demands for a given year to better represent changes in demand during extended drought periods.

4.4 Water Demand Projections

As discussed above, the water demand projection for City of Dallas Retail was developed through the DSS Model and a bottom-up approach with consideration of detailed criteria and historical data, with treated and untreated DWU Customer Cities water demand projections taken from the TWDB water demands or developed through use of 2023 water sales data and GPCD calculations. For customer cities with multiple sources of water, a percentage of its total demand was allocated to the DWU system based on historical data and held constant over the projection period. The water demand projections shown for the DWU system are average drought day demands. The drought adjustment factor of 15% has been applied to the City of Dallas Retail water demands and the eight customer cities that do not use the TWDB water demand projections, mentioned in Section 4.2.2. The remaining customer cities using the TWDB water demand projections already used 'dry year' GPCD water use data and therefore are already average drought day demands.

The estimated water demands for the DWU system are summarized in Table 4-1 through Table 4-9. Table 4-2 shows the DWU system water demand from three groups, the City of Dallas Retail, and DWU Customer Cities – treated and untreated. Table 4-3 shows City of Dallas Retail water demand disaggregated for each major pressure zone within the City of Dallas. A map of the City of Dallas' major pressure zones is shown in Figure 4-2. Table 4-4 and Table 4-5 show the treated and untreated water demand for each customer city served by DWU, respectively. Note that some customer cities show a demand that stabilizes, or even decreases over the planning period. This results from the customer city reaching a build out condition with a steady, nonincreasing population and a steady or decreasing GPCD due to plumbing code savings. Table 4-6 and Figure 4-4 provides a summary of these demands on the DWU system by presenting the City of Dallas Retail demand compared to the sum of its customer demand. Figure 4-4 graphically shows how much of the retail and customer cities make up the total demand. In Table 4-6 the values provided for City of Dallas Retail result from Table 4-3 and the projections for the DWU Customer Cities result from the total of Table 4-4 and Table 4-5 summed together.

Table 4-1 shows the GPCD values for the City of Dallas Retail and all DWU Customer Cities. The City of Dallas Retail GPCD is based on the population projections discussed in Section 3 and the drought demand projections shown Table 4-2. The drought GPCD shown for the City of Dallas Retail is consistent with the projections developed and discussed within this report.

Table 4-2 shows that in 2030, the total demand of the DWU system including retail and its customer cities is projected to be 513.1 million gallons per day (MGD). About 280.7 MGD or 54.7 percent of the total demand comes from City of Dallas Retail demand. The remaining 232.4 MGD or 45.3 percent is made up of the DWU Customer Cities demand. By 2080, total demand is expected to be 709.3 MGD with 410.4 MGD or 57.9 percent of the total demand coming from City of Dallas Retail and the remaining 298.9 MGD or 42.1 percent being from DWU Customer Cities.

Table 4-1. GPCD Values for City of Dallas Retail and DWU Customer Cities

	2030	2040	2050	2060	2070	2080
City of Dallas Retail	201	200	198	195	193	192
DWU Customer Cities Treated [a]						
Addison	362	364	364	360	363	361
Balch Springs (DCWCID #6)	88	89	90	88	90	88
Carrollton	162	161	161	161	161	161
Cedar Hill	175	174	175	175	174	175
Cockrell Hill	130	129	129	129	129	129
Combine WSC	83	73	86	75	83	88
Coppell	232	231	231	231	231	231
DFW Airport	N/A	N/A	N/A	N/A	N/A	N/A
DeSoto	150	150	150	150	150	150
Duncanville	124	122	123	123	123	123
Farmers Branch	261	259	257	258	258	258
Flower Mound	222	220	221	221	221	221
Glenn Heights (Oak Leaf)	96	95	95	95	95	95
Grand Prairie*	140	140	140	140	140	140
Hutchins	192	194	194	198	192	194
Irving	188	188	187	187	187	187
Lancaster (w/ Lancaster MUD 1)	146	145	145	145	145	145
Wilmer	119	120	127	123	119	127
Lewisville (55% Treated) (Inc Denton County FWSD 1 A)	150	150	150	150	150	150
Ovilla	202	205	204	213	208	209
Red Oak	130	129	129	129	129	129
Seagoville	96	96	96	94	95	96
The Colony	132	132	132	131	131	131
DWU Customer Cities Untreated [a]						
Grapevine	309	309	309	309	309	309
Lewisville (45% Untreated)	GPCD included above					
UTRWD (Total)	240	234	228	227	227	226
Irrigation	N/A	N/A	N/A	N/A	N/A	N/A
Dallas Service Area GPCD [b]	**191**	**190**	**189**	**188**	**187**	**186**

[a] DWU Customer Cities GPCDs shown are developed from the TWDB 2026 Region C RWP population and demand projections. GPCDs are not based on analysis conducted in Section 4.2.2.

[b] Dallas Service Area GPCD is calculated by taking the total water demands projected for these entities in gallons per day and dividing by the total system population.

Table 4-2 Water Demand Projections for City of Dallas Retail and Customer Cities

Table units: MGD

DWU System	2030	2040	2050	2060	2070	2080
Retail	280.7	302.1	326.1	351.9	378.7	410.4
Customer Cities – Treated	187.0	202.9	217.4	224.3	232.5	237.2
Treated Water Total	**467.7**	**505.0**	**543.5**	**576.2**	**611.2**	**647.6**
Customer Cities – Untreated	45.4	51.4	58.1	59.7	61.1	61.7
Total Demand	**513.1**	**556.4**	**601.6**	**635.9**	**672.3**	**709.3**

Table 4-3 Water Demand Projections for City of Dallas Retail (by Major Pressure Zones)

Table Units: MGD

City of Dallas Retail – Major Pressure Zones	2030	2040	2050	2060	2070	2080
Arcadia Park	1.9	2.0	2.1	2.2	2.3	2.4
Brooklyn Heights Intermediate	0.9	1.0	1.1	1.3	1.3	1.4
Cedar Dale High	1.4	1.5	1.6	1.7	1.9	2.0
Central Low	93.1	101.7	111.1	121.4	132.7	146.1
Cypress Waters	0.8	0.9	1.0	1.0	1.2	1.3
East High	19.2	20.4	21.7	23.1	24.4	26.0
Lone Star Intermediate	0.1	0.2	0.2	0.2	0.2	0.2
Lovers Lane Intermediate	0.4	0.3	0.5	0.5	0.5	0.6
Meandering Way High	12.0	12.9	13.9	15.1	16.8	18.6
Meandering Way Intermediate	0.8	0.9	0.9	1.0	1.0	1.2
Mountain Creek High	0.7	0.8	0.9	0.9	1.0	1.2
North High	71.7	77.7	84.4	91.5	98.2	106.1
Pleasant Grove Intermediate	18.7	19.6	20.7	22.1	23.3	24.8
Polk Street Intermediate	0.6	0.6	0.7	0.7	0.7	0.7
Red Bird High	7.0	7.5	8.0	8.7	9.2	9.9
South High	43.9	46.0	48.7	51.5	54.3	57.6
Trinity Heights Intermediate	7.3	7.8	8.3	8.7	9.4	10.0
Whispering Hills	0.2	0.3	0.3	0.3	0.3	0.3
City of Dallas Retail Total	**280.7**	**302.1**	**326.1**	**351.9**	**378.7**	**410.4**

Figure 4-2 and Figure 4-3, shown below, are heat maps displaying the City of Dallas pressure zones and the pressure zones' changes in demand over the projection period. The pressure zones expecting a significant increase in demand between 2030 and 2080 are Central Low and North High, with a moderate increase in demand expected in the

South High pressure zone. Pressure zones expecting a minor increase in demand are Whispering Hills and Lone Star Intermediate.

Figure 4-2. Major Pressure Zones for City of Dallas

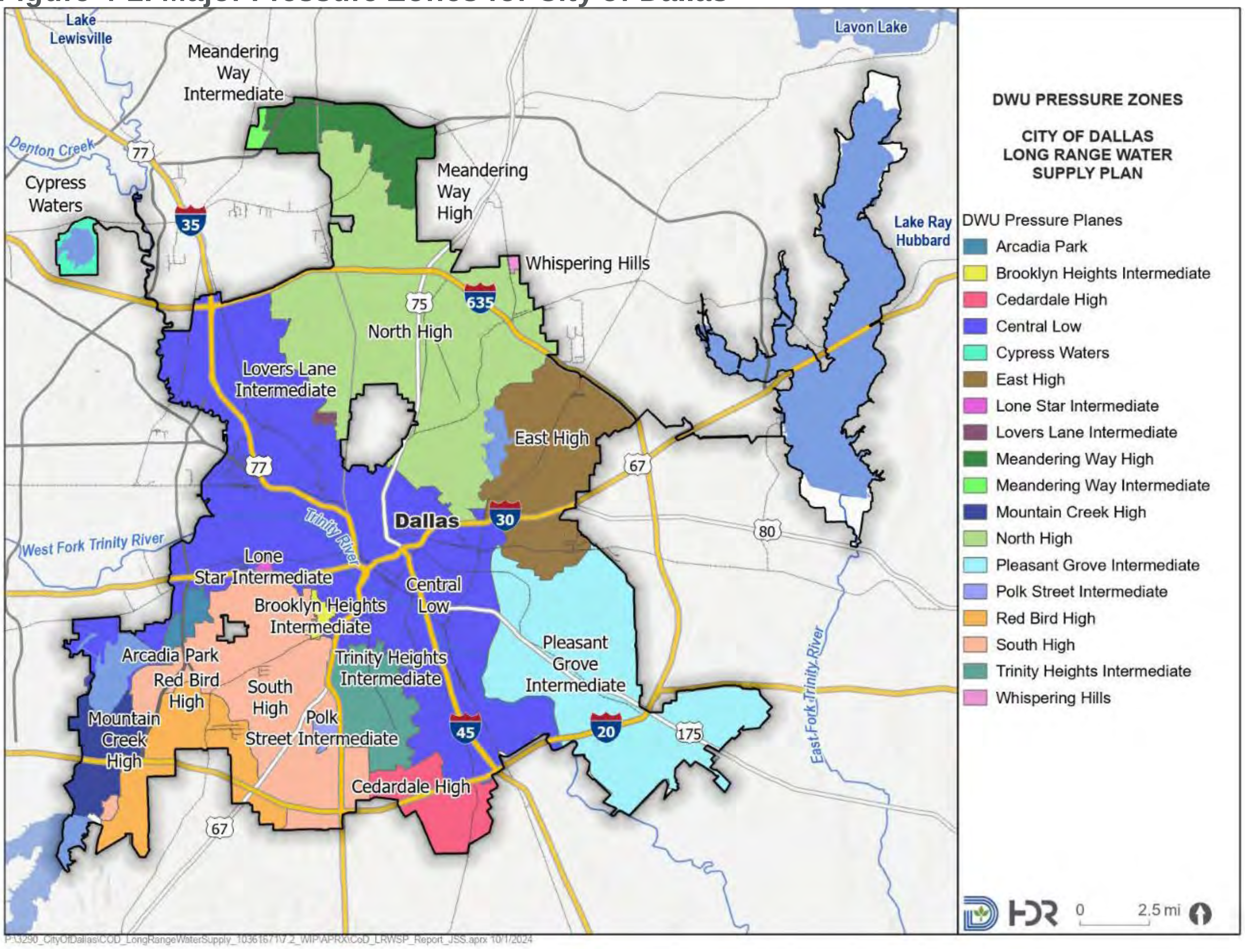


Figure 4-3. City of Dallas Retail Pressure Zone Demand Change from 2030 to 2080 (MGD)

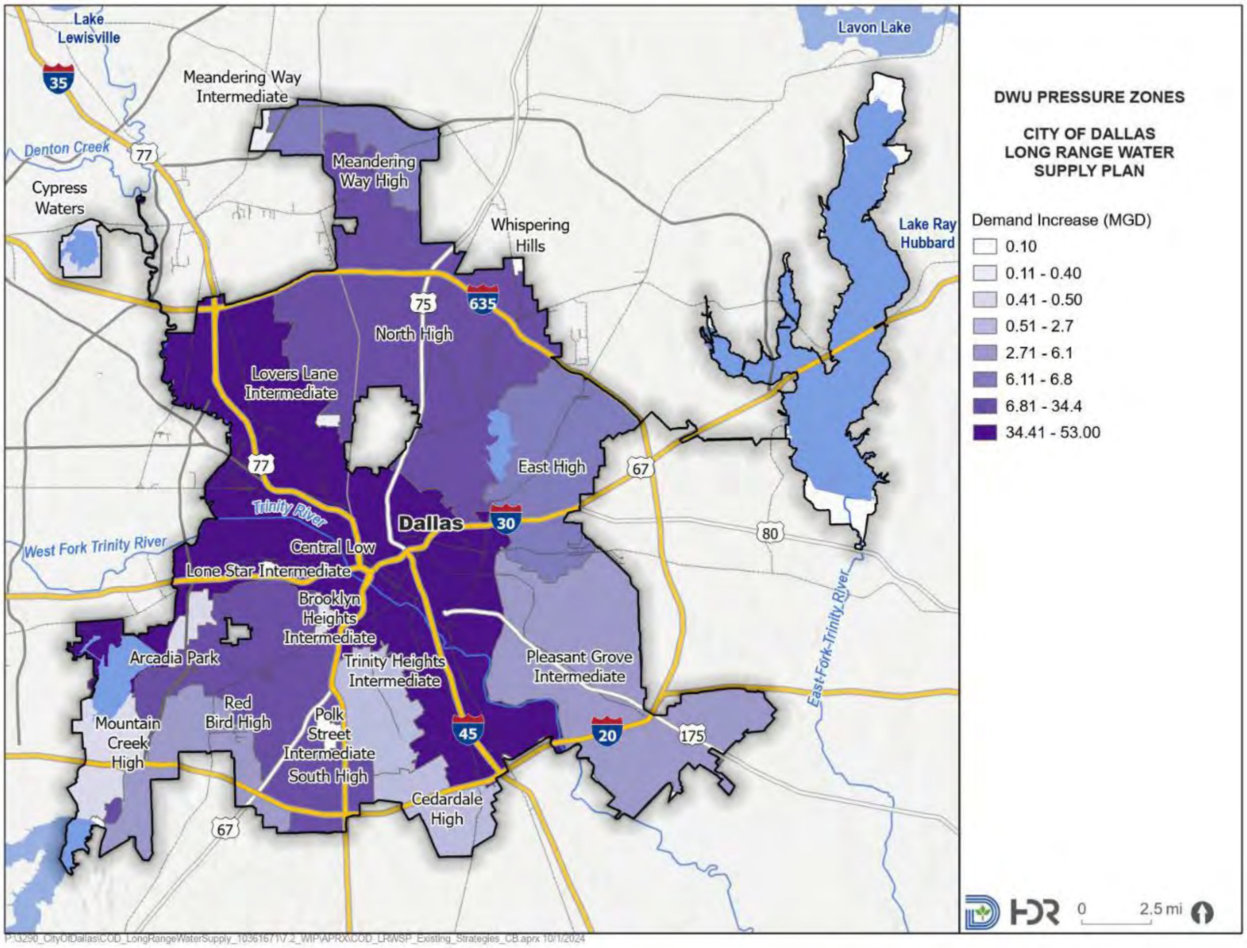


Table 4-4. Water Demand Projections for DWU Customer Cities Treated

Table units: MGD

Customer City	2030	2040	2050	2060	2070	2080
Addison	7.4	8.4	8.9	9.1	9.5	9.8
Balch Springs (DCWID #6)	2.5	2.7	3.0	3.2	3.6	3.7
Carrollton	27.6	29.1	30.8	32.6	34.5	34.7
Cedar Hill	9.4	10.2	11.2	12.1	13.0	14.1
Cockrell Hill	0.5	0.5	0.5	0.5	0.5	0.4
Combine WSC	0.3	0.3	0.4	0.4	0.5	0.6
Coppell	12.8	12.7	12.7	12.8	12.8	12.8
DFW Airport	3.1	3.3	3.5	3.6	3.7	3.9
DeSoto	12.1	12.9	13.3	13.6	13.9	14.2
Duncanville	5.4	5.6	5.8	5.8	5.8	5.8
Farmers Branch	9.5	10.3	10.7	11.0	11.3	11.6
Flower Mound	7.0	8.7	10.6	10.6	10.6	10.6
Glenn Heights (Oak Leaf)	3.5	4.1	4.6	5.1	5.6	6.2
Grand Prairie	31.4	35.0	39.3	40.4	42.0	42.0
Hutchins	1.6	1.8	1.9	2.0	2.0	2.1
Irving	19.8	21.0	21.0	21.0	21.1	21.1
Lancaster (w/ Lancaster MUD 1)	10.8	11.5	11.9	12.1	12.4	12.7
Wilmer	0.7	0.8	0.9	0.9	0.9	1.0
Lewisville (55% Treated) (Inc Denton County FWSD 1 A)	11.4	12.1	12.9	13.1	13.4	13.4
Ovilla	1.1	1.4	1.7	2.1	2.4	2.8
Red Oak	2.2	2.6	3.1	3.6	4.2	4.8
Seagoville	2.0	2.2	2.3	2.3	2.4	2.5
The Colony	4.9	5.7	6.4	6.4	6.4	6.4
Total Customer Cities Treated Demand	**187.0**	**202.9**	**217.4**	**224.3**	**232.5**	**237.2**

Table 4-5. Water Demand Projections for DWU Customer Cities Untreated

Table units: MGD

Customer City	2030	2040	2050	2060	2070	2080
Grapevine	0.8	0.8	0.8	0.8	0.8	0.8
Lewisville (45% Untreated)	9.4	10.0	10.6	10.8	11.0	11.0
UTRWD [a]	34.6	40.0	46.1	47.5	48.7	49.3
Irrigation [b]	0.6	0.6	0.6	0.6	0.6	0.6
Total Customer Cities Untreated Demand	**45.4**	**51.4**	**58.1**	**59.7**	**61.1**	**61.7**

[a] Includes Argyle WSC, Corinth, 67% of Flower Mound demands, Highland Village, Lake Cities Municipal Utility Authority, and 10 MGD of additional contractual demand.

[b] Includes Carrollton-Farmers Branch ISD, Carrollton-Indian Creek Golf Course, Garland-Firewheel Golf Course, Hickory Creek-Arrowhead Park, Highland Village-Double Tree Ranch, Rowlett-Waterview Golf Course.

Table 4-6. Water Demand Projections for DWU System and Percent of Customer Demand

Table units: MGD

DWU System	2030	2040	2050	2060	2070	2080
Retail (Table 4-3)	**280.7**	**302.1**	**326.1**	**351.9**	**378.7**	**410.4**
Customer Cities – Treated (Table 4-4)	187.0	202.9	217.4	224.3	232.5	237.2
Customer Cities – Untreated (Table 4-5)	45.4	51.4	58.1	59.7	61.1	61.7
Total Customer Cities Demand	**232.4**	**254.3**	**275.5**	**284.0**	**293.6**	**298.9**
Total Demand	**513.1**	**556.4**	**601.6**	**635.9**	**672.3**	**709.3**
Percent of Total Demand from Customer Cities	**45.3%**	**45.7%**	**45.8%**	**44.7%**	**43.7%**	**42.1%**

Figure 4-4. Water Demand Projections for City of Dallas Retail and Customer Cities

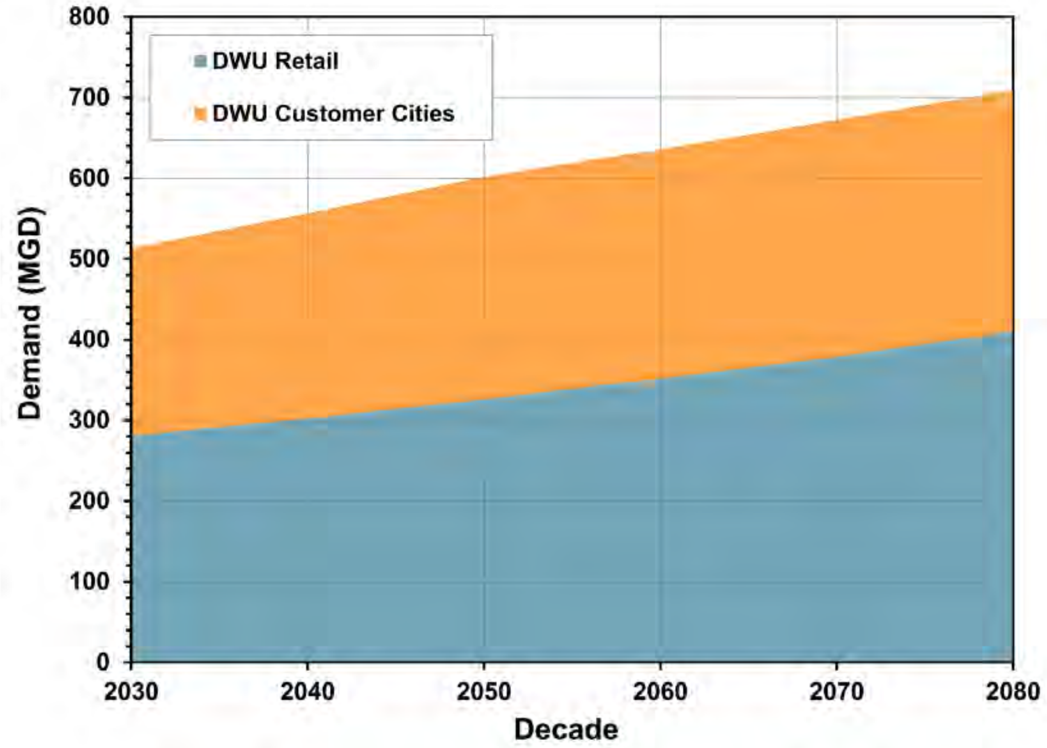


Table 4-7. DWU Customer Cities with Multiple Water Sources

Table units: MGD

Customer City	2080 Demand	% of 2080 Demand Supplied by DWU	2080 Demand Supplied by DWU	2080 Demand Supplied from non-DWU Sources
Flower Mound	32.2	33%	10.6	21.6
Glenn Heights	6.3	98%	6.2	0.1
Grand Prairie	59.2	71%	42.0	17.2
Grapevine	16.7	5%	0.8	15.9
Irving	56.9	37%	21.1	35.8
The Colony	8.9	72%	6.4	2.5

4.5 Comparison of Gallons per Capita per Day Projections

A comparison of the GPCD projections for the entire DWU service area from the 2014 LRWSP, 2026 Region C RWP, and this 2024 LRWSP are shown in Figure 4-5 and in tabular form in Table 4-8. The GPCD's from the 2026 Region C RWP and this 2024 LRWSP are very similar, with no more than 2 GPCD variation. As shown, the 2024 LRWSP GPCD projection is trending higher than the 2014 LRWSP, however, this is likely due to a more refined approach taken to project the population for the current plan. The 2024 LRWSP GPCD is anticipated to slowly decrease over the projection period due to plumbing code savings.

Figure 4-5. Comparison of GPCD Projections - 2014 LRWSP, 2026 Region C RWP, and 2024 LRWSP

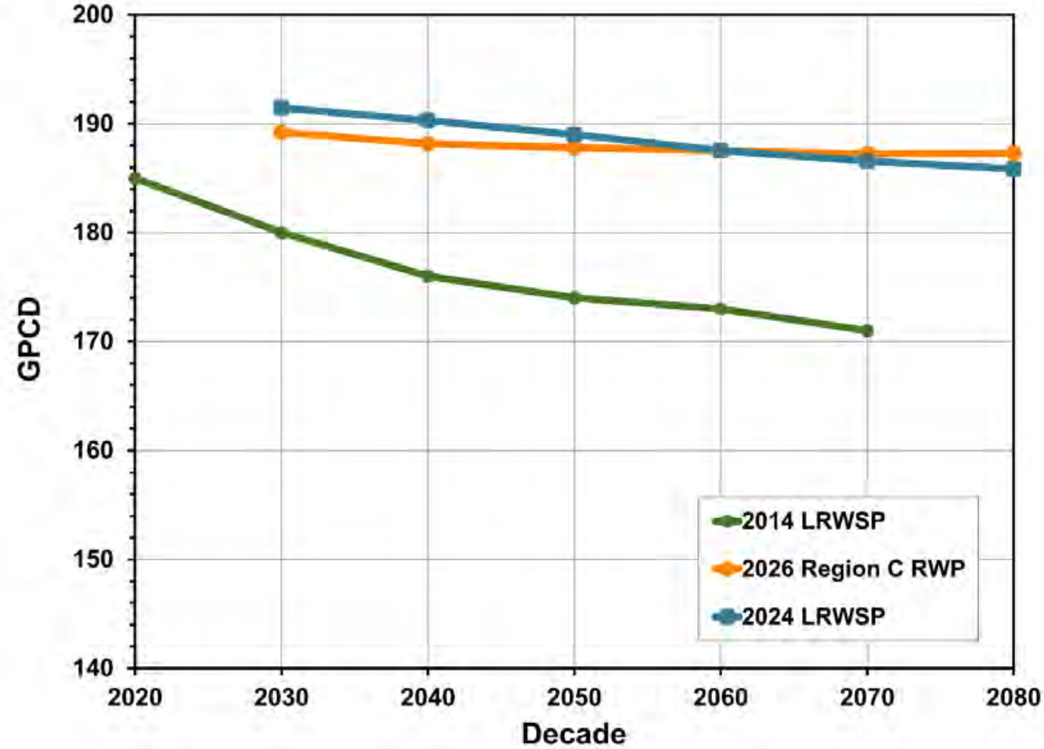


Table 4-8 Comparison of GPCD Projections - 2014 LRWSP, 2026 Region C RWP, and 2024 LRWSP

DWU GPCD Projection	2020	2030	2040	2050	2060	2070	2080
2026 Region C RWP	-	189	188	188	188	187	187
2014 LRWSP	185	180	176	174	173	171	-
2024 LRWSP	-	191	190	189	188	187	186
Percent Difference between the 2014 and 2024 LRWSP	**-**	**6.4%**	**8.1%**	**8.6%**	**8.4%**	**9.1%**	**-**

4.6 Comparison of Water Demand Projections

Water demand projections for the DWU system used in this 2024 LRWSP are compared with demands from both the 2014 Dallas LRWSP and the 2026 Region C RWP in Figure 4-6 and Table 4-9. As shown in Figure 4-6, water demands for the 2014 and 2024 LRWSP projections trend similar from 2030 to 2050. However, after 2050 projections, the 2014 LRWSP are about 40 to 50 MGD higher than the 2024 LRWSP and over 100 MGD higher than the 2026 Region C RWP. The discrepancies between the 2014 LRWSP and 2024 LRWSP can be explained through an improved process of developing the retail service area of DWU in development of the City of Dallas Retail demands. As discussed above, the 2024 City of Dallas Retail demands used a bottom-up approach that allows for multiple criteria like natural plumbing fixture replacement and plumbing codes to be input into the model to estimate future demands. The 2024 LRWSP projections trend higher than the 2026 Region C RWP over the projection period. This results from the understanding that the 2026 Region C RPW data appears to underestimate certain projections and therefore, those projections were adjusted for the 2024 LRWSP as described in Section 4.2. In 2030, the 2024 LRWSP water demand projections are 9.1 MGD higher than the 2014 LRWSP projections (a 1.8 percent increase), in 2050, the 2024 LRWSP water demand projections are 13.5 MGD lower than the 2014 LRWSP projections (a 2.2 percent decrease). Finally, in 2070, the 2024 LRWSP water demand projections are 46.1 MGD lower than the 2014 LRWSP projections (a 6.4 percent decrease).

Figure 4-6. Comparison of Water Demand Projections – 2014 LRWSP, 2026 Region C RWP, and 2024 LRWSP

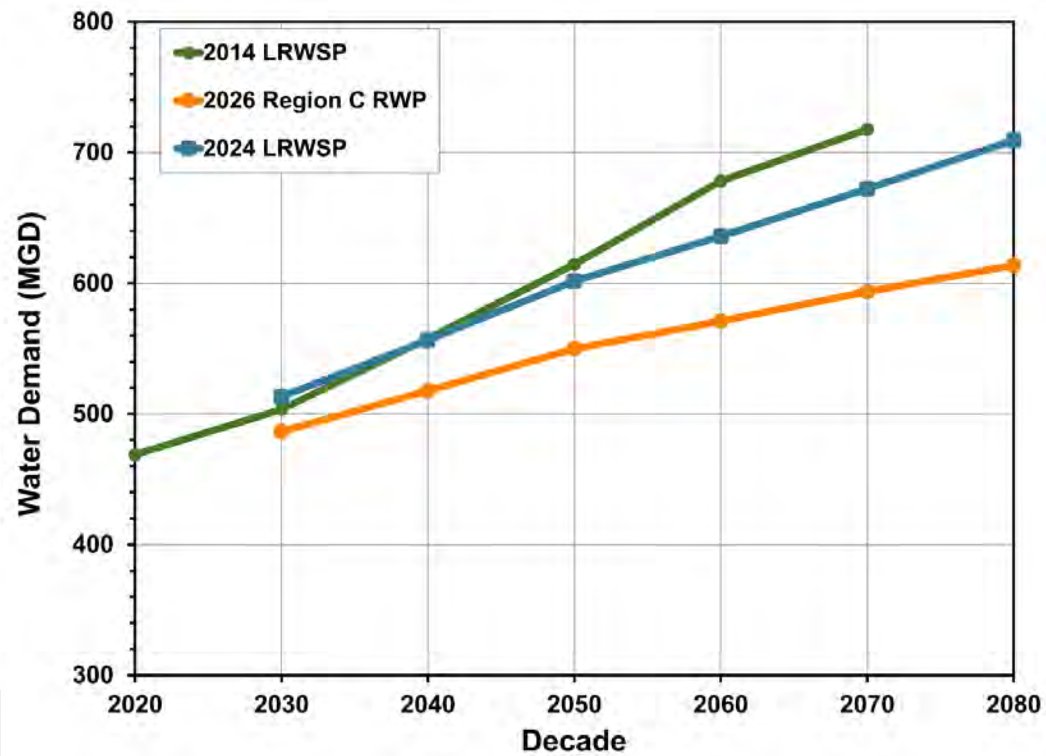


Table 4-9. 2014 LRWSP, 2026 Region C RWP, and 2024 LRWSP

Table units: MGD

DWU Demand Projection	2020	2030	2040	2050	2060	2070	2080
2026 Region C RWP	-	552.5	592.2	631.8	653.1	676.2	696.3
2014 LRWSP	468.8	503.5	557.7	614.5	678.2	717.8	-
2024 LRWSP	-	513.1	556.4	601.6	635.9	672.3	709.3
Percent Difference between the 2014 and 2024 LRWSP	**-**	**1.9%**	**(0.2%)**	**(2.1%)**	**(6.2%)**	**(6.3%)**	**-**

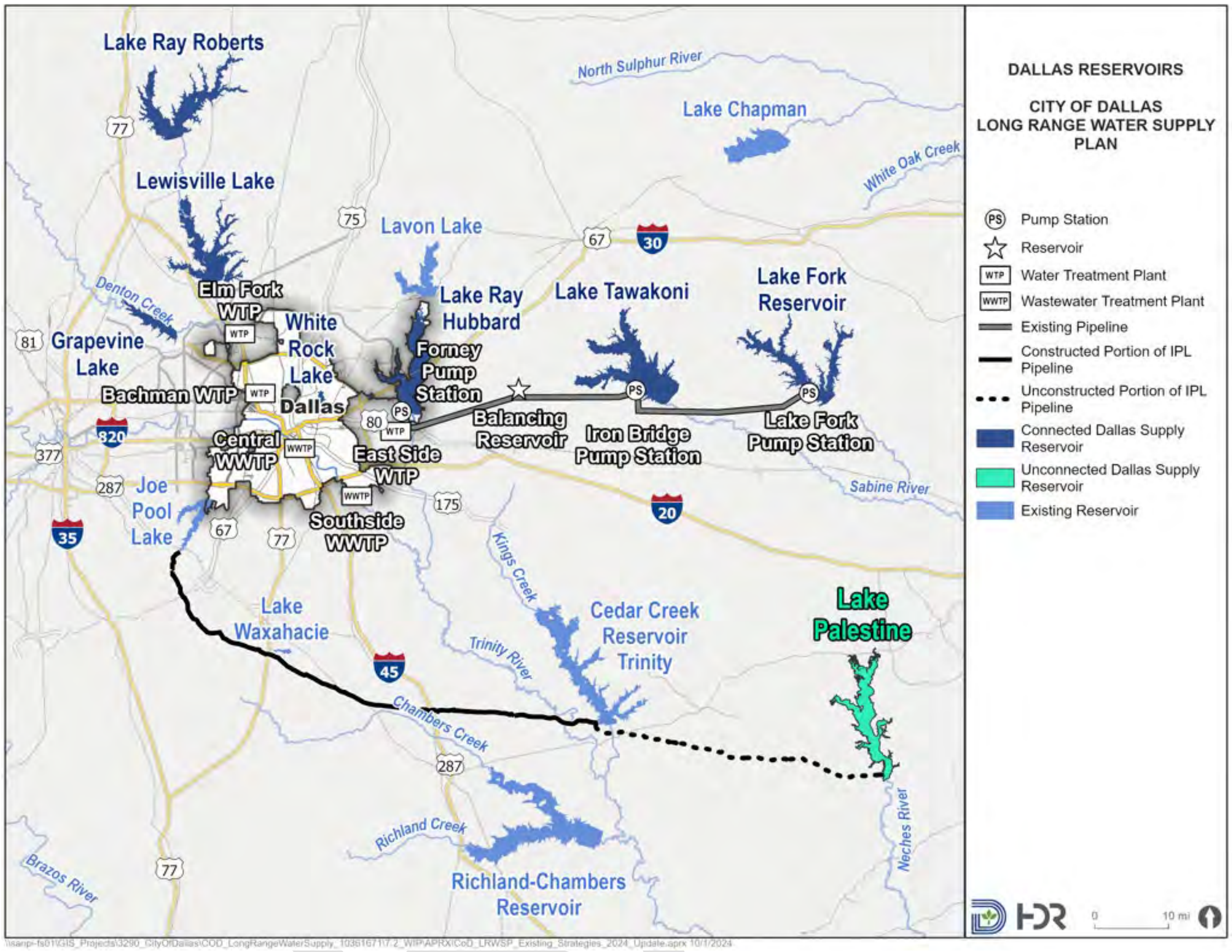
5 Water Rights and Supply

5.1 Supply System Background

The Dallas water supply system is comprised of six connected and one unconnected supply reservoirs in the Trinity, Sabine, and Neches River basins as well as run-of-river diversions from the Elm Fork of the Trinity River (Elm Fork). Dallas also has existing agreements with the Cities of Lewisville and Flower Mound for use of treated effluent return flows discharged by these cities upstream of Dallas' Elm Fork and Bachman Water Treatment Plants (WTPs).

The water supply system is divided into western and eastern subsystems to coincide with raw water deliveries to Dallas' western and eastern treatment plants. The western subsystem (Lakes Lewisville, Ray Roberts, Grapevine, Elm-Fork run-of-river sources, and reuse from City of Lewisville and Town of Flower Mound) delivers raw water to Dallas' Elm Fork and Bachman WTPs. The eastern subsystem (Lakes Ray Hubbard, Tawakoni and Fork) delivers raw water to the East Side WTP. Figure 5-1 provides the location of Dallas' supply reservoirs, major raw water transmission pipelines, and three WTPs.

Figure 5-1. Location of Dallas Reservoirs, Raw Water Pipelines, and Water Treatment Plants



Existing supplies from Dallas' reservoirs are limited by terms and conditions included in water rights and water supply contracts, the availability of water and whether supply sources are currently connected to the treatment and distribution systems. These connected supplies are assumed to not be limited by current transmission and treatment capacities in this chapter, most notably the eastern transmission pipeline which delivers supplies from Lakes Tawakoni and Fork to the East Side WTP, and treatment infrastructure capacities at Dallas' WTPs. Required expansions of existing facilities to deliver and treat raw water supplies are discussed in Chapter 8.

Unconnected supplies are sources that Dallas currently owns or has an existing contract to purchase water but require new infrastructure for delivery to the treatment system. These unconnected supplies include Lake Palestine, and treated wastewater effluent from Dallas' Central and Southside Wastewater Treatment Plants (WWTPs). Lake Palestine is planned to be connected through the Integrated Pipeline (IPL) and the treated wastewater supplies are to be connected by the Main Stem Balancing Reservoir as a recommended strategies, described in Chapter 7. White Rock Lake is not planned to be connected to Dallas' treatment system and therefore is not included in the 2024 LRWSP as a potential future supply source.

5.2 Existing Water Rights and Contracts

Certificates of Adjudication (CoA) and/or water use permits (permit) authorize the amounts of water that may be impounded and withdrawn annually from a reservoir or stream. Existing water rights either owned by Dallas or associated with existing sources are presented in Table 5-1. Additional water rights owned by Dallas that are not used for water supply are summarized in Appendix G. Assumptions regarding Dallas' portion of reservoir yields are provided in Section 5.3.4.

Table 5-1. Summary of Water Rights and Water Supply Contracts

Reservoir	River Basin	Reservoir Owner	Certificate of Adjudication or Permit No. (Owner)	Priority Dates	Dallas Portion of Authorized Diversions (MGD (acft/yr))
Western Subsystem Connected Supplies					
Lake Grapevine	Trinity	USACE	08-2458 (Dallas) 08-2362 (Grapevine & DCPCMUD#1)	Jul-1948 Sep-1951 Apr-1974	75.9 (85,000)
Lake Ray Roberts	Trinity	USACE	08-2455 (Dallas) 08-2335 (Denton)	Nov-1975 Apr-1990	528.2 (591,704)
Lake Lewisville	Trinity	USACE	08-2456 (Dallas) 08-2348 (Denton)	Jan-1924 Oct-1948 Nov-1975	491.0 (549,976)
Elm Fork Run-of-River	Trinity	Dallas	CF-75 (08-2457) (Dallas) Permit 5414 (Dallas)	Apr-1914 Apr-1984 Apr-1992	54.5 (61,309)
Eastern Subsystem Connected Supplies					
Lake Ray Hubbard	Trinity	Dallas	08-2462 (Dallas)	Feb-1955 Nov-2016	80.1 (89,700) & 106.8 MGD (119,600)[a]
Lake Tawakoni	Sabine	SRA	05-4670 (SRA) CP 1583 (Dallas)	Sep-1955	170.0 (190,480)
Lake Fork	Sabine	SRA	05-4669 (SRA) CP-450 (Dallas)	Jun-1974 Feb-1983 Aug-1985	107.1 (120,000) [b]
Unconnected Supplies					
Lake Palestine	Neches	UNRMWA	06-3254 (UNRMWA) CP-173 (Dallas)	Apr-1956	102.0 (114,337) [c]
Indirect Reuse	Trinity	Dallas	Permit 12468	Dec-2001	220.7 (247,200)

[a] Amendment I to CoA 08-2462 for the overdrafting of supplies from LRH allows up to 106.8 MGD (119,600 ac-ft/yr) of additional use on a less than firm basis for operational flexibility in addition to the originally authorized 80.1 MGD (89,700 acft/yr).

[b] Only 107.1 MGD (120,000 acft/yr) of the total authorized amount for Dallas (131,860 ac-ft/yr) is authorized for inter-basin transfer to the Trinity River basin.

[c] Dallas is contracted with UNRMWA for 53.73% of the annual dependable yield of Lake Palestine (estimated to be 102 MGD at the time of execution of the contract).

5.2.1 Western Subsystem

Dallas' western subsystem provides raw water to the Elm Fork and Bachman WTPs and is comprised of supplies from Lake Grapevine and the Elm Fork System. The Elm Fork System includes supplies from Lake Ray Roberts, Lake Lewisville, and run-of-river diversion from the Elm Fork of the Trinity River. The western subsystem also includes contracted reuse supplies from treated wastewater effluent discharges by the City of Lewisville and Town of Flower Mound.

5.2.1.1 LAKE GRAPEVINE

Lake Grapevine is owned by the United States Army Corps of Engineers (USACE) and is located in Denton and Tarrant Counties on Denton Creek, a tributary to the Elm Fork (Figure 5-1). The primary purpose of Lake Grapevine is flood control, which at times during flood conditions, may take priority over providing water supplies.

Deliberate impoundment began on July 3, 1952. Dallas has a water right (CoA 08-2458) with a priority date of July 6, 1948, to store 85,000 acft and rights to divert up to 75.9 MGD (85,000 acft/yr) for municipal, domestic, industrial, recreational, and manufacturing uses.

The City of Grapevine has a water right (CoA 08-2362) with priority dates of September 28, 1951 and April 22, 1974. These permits authorize the right to store 26,250 acft of water in Lake Grapevine and rights to divert up to 23.7 MGD (26,250 acft/yr) for municipal, domestic, and irrigation uses.

Dallas County Park Cities Municipal Utilities District #1 (DCPCMUD#1) has a water right (CoA 08-2363) with a priority date of February 11, 1946, to store 50,000 acft in Lake Grapevine with rights to divert up to 44.6 MGD (50,000 acft/yr) for municipal, domestic, industrial, and recreational uses.

In 2002, a reservoir operating agreement was executed between the City of Dallas, Grapevine, and the DCPCMUD#1 which further regulates diversions from the reservoir by each entity. Dallas' water right and the operating agreement for Lake Grapevine do not stipulate a yield share percentage. Dallas estimates that approximately 41% of the firm yield of Lake Grapevine is available for supply based on actual lake operations and considering the reservoir accounting plan. The accounting plan is a spreadsheet that tracks daily diversions from the lake by each of the entities to ensure compliance with the terms and conditions of the water rights.

5.2.1.2 LAKE RAY ROBERTS

Lake Ray Roberts is owned by the USACE and is located at the confluence of the Elm Fork of the Trinity River and Isle Du Bois Creek (Figure 5-1). The primary purpose of Lake Ray Roberts is flood control, which at times during flood conditions, may take priority over providing water supplies.

Dallas has a water right (CoA 08-2455) with a priority date of November 24, 1975, which authorizes the storage of 591,704 acft and diversions of up to 528.2 MGD (591,704 acft/yr) for municipal and domestic purposes. This CoA has been amended so that 102.8 MGD (115,100 acft/yr) of the 528.2 MGD (591,704 acft/yr) can be used for hydroelectric purposes by the City of Denton with the remaining allocation of 425.5 MGD (476,604 acft/yr) expanded to include irrigation, industrial, and recreational uses. The City of Denton rights for hydroelectric use have not been exercised as a hydroelectric plant has not been built. In October 2011, Denton withdrew its Federal Energy Regulatory Commission (FERC) license for hydroelectric generation at Ray Roberts and the FERC approved the withdrawal in 2013.

The City of Denton has a water right (CoA 08-2335) with a priority date of November 24, 1975. This CoA authorizes the storage of 207,896 acft in Lake Ray Roberts and the diversion of up to 185.6 MGD (207,896 acft/yr) for municipal, domestic and hydroelectric purposes. Denton's rights to divert water from Lake Ray Roberts (and Lake Lewisville) are limited through water supply and return flow sharing agreements with the City of Dallas.

5.2.1.3 LAKE LEWISVILLE

Lake Lewisville is owned by the USACE and is located in Denton County on the Elm Fork downstream of Lake Ray Roberts (Figure 5-1). The primary purpose of Lake Lewisville is flood control, which at times during flood conditions, may take priority over providing water supplies.

Deliberate impoundment at Lake Lewisville began on November 1, 1954. Prior to the construction of Lake Lewisville, Dallas operated Lake Dallas at a site 9.4 miles upstream of the Lake Lewisville dam site. Deliberate impoundment at Lake Dallas began on February 16, 1928, and the lake is estimated to have stored 194,000 acft when it was initially constructed.

Dallas has a water right (CoA 08-2456) with priority dates of January 25, 1924, October 5, 1948, and November 24, 1975, to store 549,976 acft in Lake Lewisville and rights to divert up to 491.0 MGD (549,976 acft/yr) for municipal, domestic, industrial, irrigation, recreational and hydroelectric power generation (non-consumptive) uses.

The City of Denton also has a water right (CoA 08-2348) to impound a total of 68,424 acft of water in Lake Lewisville and to divert a total of 52.1 MGD (58,424 acft/yr) for municipal and domestic uses. Denton's water right allows for the storage of 21,000 acft (of the total 68,424 acft) and diversion of 9.8 MGD (11,000 acft/yr) (of the total 52.2 MGD) for municipal and domestic uses with a priority date of November 24, 1948. The remaining storage of 47,424 acft and diversion amount of 42.3 MGD (47,424 acft/yr) has a priority date of November 24, 1975.

5.2.1.4 ELM FORK RUN OF RIVER

Dallas holds several water rights which allow diversion of water from the Elm Fork of the Trinity River, which provides water to Dallas' Elm Fork and Bachman WTPs. The water in the Elm Fork consists of stored water released from Lakes Lewisville and Grapevine and return flows from two wastewater treatment plants (WWTPs), as operated by the cities of Lewisville and Flower Mound, as well as run-of-the-river water originating downstream of Lakes Lewisville and Grapevine.

The water from the pool at Frazier Dam is diverted to Dallas' Bachman WTP located adjacent to Bachman Reservoir on the Bachman Branch tributary. The water from the pool at Carrollton Dam is diverted to Dallas' Elm Fork WTP. Dallas has a water right CoA 082457 referred to as CF-75 with a priority date of April 22, 1914, to divert 17.3 MGD (19,381.4 acft/yr) for municipal, domestic, recreational and irrigation uses from the Old Channel of Elm Fork Trinity River. CF-75 also authorizes Dallas to divert 1.7 MGD (1,927.8 acft/yr) from Bachman Reservoir. This right is not subject to any special streamflow conditions limiting diversions and includes authorization for Dallas to store water impounded within five small channel reservoirs including:

- 49 acft at Record Crossing Dam;
- 517 acft at California Crossing Dam at the April 22, 1914 priority date and an additional 3,083 acft at a April 9, 1984 priority date;
- 998 acft at Carrollton Dam and Reservoir;
- 651 acft at Frazier Dam and Reservoir; and
- 2,302 acft at Bachman Reservoir.

The City of Dallas also owns an April 2, 1992, run-of-river water right (Permit No. 5414) authorizing a combined 35.7 MGD (40,000 acft/yr) of diversions from the Elm Fork Trinity River at its Bachman and Elm Fork WTP diversion sites. This right is subject to a combined diversion rate of 640.73 cfs from the two diversion sites and includes special environmental flow conditions, which Dallas is required to honor that periodically limit diversions. Total diversions for Elm Fork Run-of-River equal 61,309.2 [19,381.4 (CF-75 from Trinity River) +1,927.8 (CF-75 from Bachman Reservoir) + 40,000 (Permit No. 5414 from Trinity River)] acft/yr.

5.2.1.5 CITY OF LEWISVILLE AND TOWN OF FLOWER MOUND RETURN FLOWS

Dallas has agreements for the use of treated effluent discharged by the City of Lewisville and Town of Flower Mound. Dallas obtained the right to divert and reuse water from its Central and Southside WWTPs, along with the discharges of Lewisville and Flower Mound from Lewisville Lake (97,200 acft/yr under Certificate of Adjudication 08-2456E), and from Lake Ray Hubbard (150,000 acft/yr under Certificate of Adjudication 08-2462G).

By permit issued on March 31, 2010, Dallas severed the indirect water reuse rights from the reservoir permits, and combined them in a separate permit, Water Use Permit No. 12468, which incorporates all Dallas' rights to storage and indirect reuse of effluent return flows from both Lewisville Lake and Lake Ray Hubbard in the one permit.

At this time, the return flows of the City of Lewisville and the Town of Flower Mound are connected to Dallas' water system and authorized to be used under an Accounting Plan approved by the Texas Commission on Environmental Quality (TCEQ). The accounting plan is a spreadsheet that tracks daily discharges and diversion of return flows to ensure compliance with the terms and conditions of the permit.

5.2.1.6 LAKE PALESTINE

Lake Palestine is owned by the Upper Neches River Municipal Water Authority (UNRMWA) and is located on the Neches River in Henderson, Smith, Anderson, and Cherokee Counties (Figure 5-1). Deliberate impoundment began on May 1, 1962. In accordance with CoA 06-3254, the UNRMWA is authorized to store 411,840 acft and has a right to divert 212.6 MGD (238,110 acft/year) for municipal, domestic, irrigation, and industrial uses. Additionally, UNRMWA also has the right to divert 41.1 MGD (46,000 acft/year) from the Downstream Diversion Dam for municipal and industrial uses. UNRMWA is authorized to transfer 118.1 MGD (132,337 acft/year) to the Trinity River Basin of which 102 MGD can be diverted from Lake Palestine and the remaining interbasin transfer amount must be diverted at the Downstream Diversion Dam.

Dallas is contracted with UNRMWA for 53.73% of the annual dependable yield, estimated to be 102.0 MGD on average (114,337 acft/yr) at the time of the contract execution, from Lake Palestine. Lake Palestine is planned to be connected to the Dallas western system by the IPL. UNRMWA is limited in the amount of water it can provide Dallas from Lake Palestine by the stipulation that only 102 MGD from Lake Palestine can be diverted from the Neches to Trinity River Basin by Certificate of Adjudication No. 06-3254B. Dallas does not currently have a contract for the additional water authorized for interbasin transfer from the Downstream Diversion Dam.

5.2.2 Eastern Subsystem

Dallas's eastern subsystem supplies the East Side WTP and is comprised of supplies from Lake Ray Hubbard, Lake Tawakoni, and Lake Fork.

5.2.2.1 LAKE RAY HUBBARD

Lake Ray Hubbard (LRH) is owned by the City of Dallas and is located just downstream of Lake Lavon on the East Fork of the Trinity River (Figure 5-1). Deliberate impoundment began on December 1, 1968. The City of Dallas has a water right (CoA 08-2462) with a priority date of February 2, 1955, to store up to 490,000 acft and to divert up to 80.1 MGD (89,700 acft/yr) for municipal, domestic, industrial, irrigation, mining, hydroelectric, recreation and domestic and livestock uses.

On November 15, 2016, Dallas was granted an amendment to Certificate of Adjudication 08-2462 for the overdrafting of supplies from LRH. The overdrafting authorization allows up to 106.8 MGD (119,600 acft/yr) of water on a less than firm basis in addition to the originally authorized 80.1 MGD (89,700 acft/yr) from LRH for operational flexibility. This permit amendment allows for greater operational efficiency on Dallas' eastern subsystem by allowing overdrafting, or diverting an annual amount greater than the firm yield during non-drought conditions, from Lake Ray Hubbard when water is available, thereby providing operational flexibility to reduce diversions and pumping costs associated with delivering water from Lakes Tawakoni and Fork.

5.2.2.2 LAKE FORK

Lake Fork Reservoir (or Lake Fork) is owned by the Sabine River Authority (SRA) and is located in Wood, Rains, and Hopkins Counties on Lake Fork Creek (Figure 5-1). The SRA has a water right (CoA 05-4669) to store 675,819 acft in Lake Fork and to divert up to 168.3 MGD (188,660 acft/yr) for municipal and industrial purposes. Of the total diversion amount, 107.1 MGD (120,000 acft/yr) is allowed to be transferred to the Trinity River basin. In addition, CoA 05-4669 authorizes Dallas and the SRA to operate Lake Fork and Lake Tawakoni as a system and to divert water from one reservoir to be diverted through either reservoir.

Dallas has a contract with SRA for the purchase of up to 117.7 MGD (131,860 acft/yr) of raw water and has a pipeline which connects the reservoir to both Lake Tawakoni and Dallas' East Side WTP. The construction of Lake Fork Reservoir began in October 1975 and was completed in February 1980. Deliberate impoundment began on June 29, 1979, and the water level first reached conservation pool elevation in December 1985.

5.2.2.3 LAKE TAWAKONI

Lake Tawakoni is owned by the (SRA and is located on the Sabine River in Rains, Van Zandt, and Hunt Counties (Figure 5-1). The SRA has a water right (CoA 05-4670) to store 927,440 acft in Lake Tawakoni and to divert up to 212.4 MGD (238,100 acft/yr) for municipal and industrial purposes. Dallas CoA 05-4670 authorizes a combined transfer of 203.1 MGD (227,675 acft/yr) from Lakes Fork and Tawakoni to the Trinity River basin.

Dallas has a contract with SRA for the purchase of up to 80% of the total authorization equivalent to 169.9 MGD (190,480 acft/yr) of raw water and operates a pipeline which connects the reservoir to Dallas' East Side WTP. Construction of Lake Tawakoni (Iron Bridge Dam) began in January 1958 and was completed in December 1960. Deliberate impoundment began on October 7, 1960, and the water level first reached conservation pool elevation on February 11, 1965.

5.2.3 Dallas Return Flows

In the early 2000's, Dallas obtained the right to divert and reuse water from its Central and Southside WWTPs. This authorization includes diversion of discharges from the City of Lewisville and the Town of Flower Mound. The water right authorized diversion of Dallas' return flows from Lewisville Lake (86.8 MGD or 97,200 acft/yr under CoA 08-2456E), and from Lake Ray Hubbard (133.9 MGD or 150,000 acft/yr under CoA 08-2462G). By the permit issued on March 31, 2010, Dallas severed the indirect water reuse rights from the reservoir permits and combined them in a separate permit, Permit No. 12468, which incorporates all of Dallas' rights to store and use return flows from both Lewisville Lake and Lake Ray Hubbard in the one permit. Dallas' indirect reuse permits are summarized in Table 5-2.

Table 5-2. Summary of Dallas Reuse Permits

Certificate of Adjudication No. or Permit No.	Priority	Authorization
Permit No. 12468 (Combines CoA 08-2456E & CoA 08-2462G)	Dec-2001	Authorizes 220.7 MGD (247,200 acft/yr) for indirect reuse from Lewisville Lake and Lake Ray Hubbard
Amendment A & B of Permit No. 12468A	Dec-2001	Authorizes use of 87.6 miles of the bed and banks of the Upper Trinity River for the transport and diversion of return flows from Dallas' Central and Southside WWTPs.

Dallas has the right to use the bed and banks of the Trinity River downstream from the Central WWTP discharge to a point 87.6 miles downstream on the Trinity River for subsequent diversion of these return flows. Use of the bed and banks to transport Dallas' treated wastewater effluent allows Dallas to satisfy the terms of the December 2008 Contract between City of Dallas and North Texas Municipal Water District (known as the Swap Agreement) under which Dallas can swap its permitted reuse from Central WWTP and Southside WWTP for an equal amount of NTMWD reuse in Lake Ray Hubbard. Under the agreement Dallas can also develop an alternate source for the swap of water to supply the District's East Fork Raw Water Treatment Project in lieu of its own reuse from CWWTP and SSWWTP. The NTMWD project is a wetlands project and mitigation bank currently supplied, in part, by Dallas' release of NTMWD effluent previously discharged into Lake Ray Hubbard.

5.3 Water Availability Modeling Assumptions

This section outlines the assumptions made to determine the drought reliable supply available from Dallas' existing water supply sources under current (2030) and future (2080) conditions.

5.3.1 Primary Model Assumptions

Water availability analyses for current (2030) and future (2080) conditions were performed using Dallas' RiverWare model to estimate the firm yield of all supply reservoirs during historical drought periods within the 1907-2020 model period of record. In a multi-reservoir system as complex as Dallas', there are many assumptions required to appropriately characterize each modeling scenario used to calculate reservoir yields. Key assumptions are listed in Table 5-3 for current and future conditions. More detailed descriptions of each model component are provided in Appendix O.

Table 5-3. Model Components and Assumptions for Yield Analyses

Model Components	Simulation Year	
	Current (2030)	Future (2080
Reservoir Sediment Conditions	2030	2080
Flood Pool Storage and Operations	Yes	Yes
Diversions from Dead Pool Storage	No	No
Projected Temperature Increase from Historical (°F)[D]	3	8
Naturalized Flow Set	Baseline	Baseline
Lake Ray Hubbard Inflows [A]	Historical	Historical
Senior Water Rights Pass Throughs [B]	Yes	Yes
Senior Water Rights Upstream Depletions [B]	Yes	Yes
Return Flows (2020 levels) [C]	Yes	Yes

[A] The drainage area below Lake Lavon and above Lake Ray Hubbard (LRH) has experienced significant urbanization. One impact of urbanization is increases in storm runoff from increases in impervious surfaces. The model has the option to utilize historical TCEQ WAM inflows with no adjustments for urbanization and to adjust inflows under ultimate build-out conditions (current condition of watershed). Historical inflows were assumed to estimate the supply available to Dallas from LRH. See Section 5.3.3 Overdrafting and Operational Flexibility for additional information.
[B] Reservoir inflows and run-of-river diversions are adjusted for both upstream senior water rights and pass-throughs for downstream senior water rights so that reservoir yields reflect the impact of senior water rights.
[C] These return flows include the estimates in the Dallas RiverWare model and are estimated using historical return flows occurring from 2008-2020. Increases in return flows in the Elm Fork of the Trinity River since 2020 and those that are projected to occur in the future are not included in the reservoir supplies. These increases are accounted for in the LRWSP as a separate supply source (Additional Elm Fork Return Flows).
[D] Temperature increases are projected from historical averages for 1961-1990.

Current and future conditions consider projected sediment conditions and temperature conditions for all reservoirs currently connected to Dallas' supply system. Elevation-area-capacity tables for 2030 and 2080 sediment conditions for each reservoir are included in Appendix H and include both the conservation pool capacities and dead pool storages used for all model simulations. For consistency with the Texas Water Development Board (TWDB) Regional Water Plans (RWPs), 2030 and 2080 elevation-area-capacity relationships from the ongoing 2026 Region C planning effort were used in the 2024 LRWSP evaluation.

Projected increases in temperature were based on climate model predictions and the associated increases in reservoir evaporation. Climate models predict an increase in average annual daily high temperatures of 3°F from the historical annual average of daily high temperatures by 2030 and an 8°F increase from the historical annual average of daily high temperatures by 2080. Further discussion of the procedures used to estimate additional evaporative losses from projected temperature increases are included in Appendix I.

5.3.2 Firm Yield Assumptions

Firm yield is defined as the annual demand on a reservoir that will not reduce lake levels below dead pool storage levels during a repeat of the most severe historical drought. Using the firm yield to estimate supplies is consistent with previous DWU planning studies and current operational policies.

To mitigate the potential risk of future droughts more severe than those on record and potential supply emergencies, projected temperature increases and associated increases in evaporative losses from Dallas' reservoirs are included in the yield calculations and reservoirs are modeled independently of each other. The geographic diversity of Dallas' reservoirs and flexibility of the transmission, treatment and distribution facilities also allows DWU to increase supply reliability through system operations (over- and under-drafting reservoirs depending on drought conditions in the individual reservoir watersheds). Treating each reservoir as an independent supply source conservatively excludes the additional supply created from system operations.

5.3.3 Overdrafting and Operational Flexibility Assumptions

Significant urbanization has occurred in the LRH watershed since the occurrence of the most severe drought on record (1950's drought), increasing the amount of runoff generated from rainfall and ultimately impounded in LRH. In 2016, Dallas was granted an amendment to CoA 08-2462 for the overdrafting of supplies from LRH. The overdrafting authorization allows up to 106.8 MGD (119,600 ac-ft/yr) of water on a less than firm basis in addition to the originally authorized 80.1 MGD (89,700 acft/yr) from LRH for operational flexibility.

This overdrafting capability allows Dallas to divert more than the firm yield amount from LRH when storage levels are high during non-drought periods. When storage levels are lower during severe drought periods, Dallas can reduce diversions from LRH to less than the firm yield amount, or under-draft, and rely more on Lakes Fork and Tawakoni to supply the eastern subsystem. The overdrafting and under-drafting capability provides the operational flexibility to reduce diversions and pumping costs associated with delivering water from Lakes Tawakoni and Fork as severe drought periods are less frequent that non-drought periods. In other words, the overdrafting capability allows Dallas to use more of the less expensive LRH supplies most of the time without impacting the reliability of the eastern subsystem to deliver water during drought periods.

While the Dallas RiverWare model has the capabilities to adjust historical inflows for the change in land use, the firm yield supply for LRH in the 2024 LRWSP assumes the additional runoff and associated interruptible supply is reserved for overdrafting to support operational flexibility. Therefore, the firm yield of LRH is conservatively assumed to be 49.7 mgd for the 2030-2080 planning horizon and is based on the available streamflows included in the TCEQ Trintiy WAM used for evaluating water right applications (TCEQ Trinty WAM Run 3) which does not include adjustments for the urbanization of the LRH watershed and is consistent with the Region C Regional Water Plan assumptions[1].

However, it is assumed that decreases in the firm yield supplies of LRH from the loss of storage due to sediment accumulation and projected temperature increases will be able to be overcome with supplies from a portion of the 106.8 MGD overdrafting authorization

[1] During the permit application process for the overdrafting amendment to Certificate of Adjudication 08-2462, TCEQ did not recognize the concept of the additional runoff created by urbanization in the watershed.

during the 2080 planning horizon; therefore, the firm supply available to Dallas remains at 49.7 MGD for the 2030-2080 planning horizon in the 2024 LRWSP.

5.3.4 Dallas Portion of Reservoir Yields

Dallas operates most of its reservoirs with other entities or partners. A review of Dallas' agreements with these other entities was performed by Dallas' water rights attorneys for the 2014 LRWSP to estimate the percentage of supply or yield that Dallas has rights to from each of its water supply reservoirs. These percentages are assumed to still be applicable for the 2024 LRWSP and are summarized in Table 5-4 which shows Dallas' portion of reservoir yields assuming that all entities would be entitled to the same percentage of reservoir firm yield as defined under existing contracts.

Table 5-4. Dallas' Portion of Reservoir Yields

Reservoir	Dallas Percentage of Yield	Other Entities that Share Yield
Lake Grapevine[a]	41%	Grapevine, Park Cities MUD
Lake Ray Roberts	74%	Denton
Lake Lewisville	95.2%	Denton
Lake Ray Hubbard	100%	---
Lake Tawakoni	80%	SRA
Lake Fork	74%	SRA
Lake Palestine[b]	53.73%	UNRMWA
Elm Fork Run of River	100%	---
Elm Fork Return Flows	100%	---

[a]Dallas' contract for Lake Grapevine water does not stipulate a yield share percentage. The 41% value was provided by Dallas staff during the 2014 LRWSP and is based on actual lake operations and considering the reservoir accounting plan that stipulates diversion limits for each of the three entities that have rights in the reservoir.

[b]Dallas' contract with UNRMWA for Lake Palestine water stipulates that its share is 53.73% of the annual dependable yield, estimated to be 102.07 MGD (114,337 acft/yr) at the time of contract execution. UNRMWA's Certificate of Adjudication No. 06-3254B also limit the amount of water diverted from Lake Palestine which can be transferred from the Neches River Basin to the Trinity River Basin at 102.07 MGD.

5.3.5 Return Flow Availability Assumptions for Reservoir Yields

The Dallas RiverWare model includes 2020 levels of return flows that are discharged upstream of Dallas' reservoirs and are available for impoundment. The 2020 levels are estimated based on reported discharges for 2008-2020 and do not include projected increases beyond 2020. The 2020 level return flows included in the Dallas RiverWare model contribute to the firm yield of the individual reservoirs.

The projected increases in return flows in excess of 2020 levels which are not included in the Dallas RiverWare model and which are available to Dallas through existing permits and agreements (City of Lewisville and Town of Flower Mound return flows) are considered a separate supply source in the 2024 LRWSP. These additional return flow amounts in Dallas' western subsystem (Elm Fork System) are determined based on estimates in the TWDB database for the 2027 Regional Water Plans (DB27) as included in Report #4 – WUG Existing Water Supplies of the May 2024 Region C Regional Water

Planning Group Technical Memorandum. (See Trinity Indirect Reuse for Dallas). The Elm Fork System 2020 levels of return flows included in the Dallas RiverWare model and the estimated additional Elm Fork System Return flows for 2030-2080 are provided in Table 5-5.

Table 5-5. Summary of Additional Elm Fork System Return Flows(MGD)

Source	2030s	2040	2050	2060	2070	2080
Dallas County[a]	26.6	27.9	30.1	36.1	40.1	40.1
Collin County[a]	1.1	1.3	1.5	1.9	2.3	2.4
Denton County[a]	0.8	0.9	1.2	1.6	2.1	2.4
Total	**28.5**	**30.1**	**32.8**	**39.6**	**44.5**	**44.9**
How Above Return Flows were Modeled in 2024 LRWSP						
2020 level Return Flows included in Dallas Water Supply Model and Reservoir Yields	**14.7**	**14.7**	**14.7**	**14.7**	**14.7**	**14.7**
Additional Elm Fork System Return Flows not included in Dallas Water Supply Model	13.8	15.4	18.1	24.9	29.8	30.2

[a] April 2024 Region C Regional Water Planning Group Technical Memorandum in Report #4 – WUG Existing Water Supplies. See Dallas (WUG)/Trinity Indirect Reuse (Source Description) on pages 71, 79, and 86 of the PDF.

The 2024 LRWSP existing supplies evaluation does not assume the swap agreement with the North Texas Municipal Water District (NTMWD) is an existing supply because the contract between Dallas and NTMWD has not been finalized. Therefore, current and future NTMWD return flows that enter LRH are assumed to not be available to Dallas and do not contribute to the yield of the reservoir. This potential supply is considered a strategy and not an existing supply in the 2024 LRWSP.

5.3.6 Supply Buffer

To account for the uncertainty associated with supply under future conditions, the 2024 LRWSP carries a supply buffer goal of at least 10% for the timing of additional supplies from water management strategies. In other words, Dallas strives to maintain at least 10% firm supply above projected demands to mitigate future droughts more severe than those historically occurring. The supply buffer is shown in the implementation plan presented in Chapter 6.

5.4 Connected Supplies

The Dallas RiverWare model was utilized to estimate the firm yield of Dallas' connected water supply reservoirs during severe drought periods within the 1907-2020 model simulation period. During this 114-year timeframe, there were three severe droughts that extended throughout northeast Texas. These included the 1908 drought which occurred from 1908 to 1913, the 1950's drought which occurred from 1951 to 1957, and the more recent drought occurring from 2010 to 2014. Dallas' portion of reservoir firm yields (described in section 5.3.4) were applied to the calculated reservoir firm yields to determine Dallas' reservoir supply. Dallas' supply under current (2030) and future (2080) conditions and supply loses due to sedimentation and climate change are summarized in the following sections. Note that Lake Palestine is not included in Dallas' supply totals because it is not currently a connected supply source. Supply from Lake Palestine is considered an unconnected supply and is part of a water supply strategy in the 2024 LRWSP.

5.4.1 Current (2030) Existing Supplies

Table 5-6 and Figure 5-2 provide Dallas' supply under current (2030) conditions and demonstrate that there is not a significant difference in the sum of the current supplies of Dallas' existing reservoirs for the 1908 and 1950's droughts. However, the 1950s drought is more severe for Dallas' primary sources including the Elm Fork System and LRH.

The 1908 drought is more severe for Dallas' eastern reservoirs (Lakes Tawakoni and Fork). However, these reservoirs are not planned to be utilized as frequently with the overdrafting capabilities of LRH and are planned to be operated to support LRH during severe drought conditions in the LRH watershed.

Additionally, the Region C Regional Water Plan utilizes the 1950s drought as the drought of record. For consistency with the RWP and to prioritize supplies from Dallas' primary reservoirs, the 2024 LRWSP utilizes the 1950's drought supply numbers for comparison with demands to determine needs.

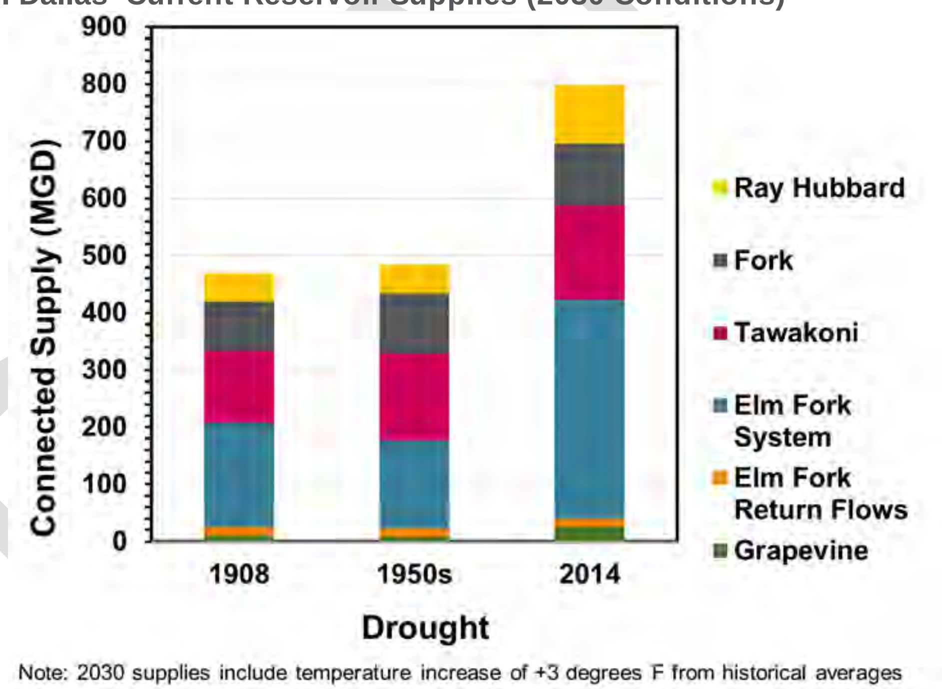
Figure 5-2 also compares the more recent drought to the 1908 and 1950s drought. It should be noted that the 2014 drought occurred after the LRH watershed had been heavily urbanized and historical inflows used in the model simulation include the "additional runoff". However, based on the model simulations, the recent drought is not as severe as the 1908 and 1950s drought as illustrated by the larger supply amounts available under the recent drought conditions (2010-2014) shown in Table 5-6 and Figure 5-2.

Table 5-6. Dallas' Current Supplies (2030 Conditions)[a]

Reservoir	Supply (MGD)		
	1908 Drought	1950's Drought	Recent Drought (2010-2014)
Lake Grapevine	10.8	9.2	26.6
Elm Fork System	183.7	154.0	382.9
Additional Elm Fork System Return Flows	13.8	13.8	13.8
West Subsystem	208.3	177.0	423.3
Lake Ray Hubbard	50.3	49.7	103.4
Lake Tawakoni	125.0	152.1	164.1
Lake Fork	85.6	105.3	107.2
East Subsystem	260.9	307.1	374.7
Total System	469.2	484.1	798.0

[a] Yields account for increased evaporation from a 3°F increase in temperature from the historical average due to climate change.

Figure 5-2. Dallas' Current Reservoir Supplies (2030 Conditions)



5.4.2 Future (2080) Existing Dallas Supplies

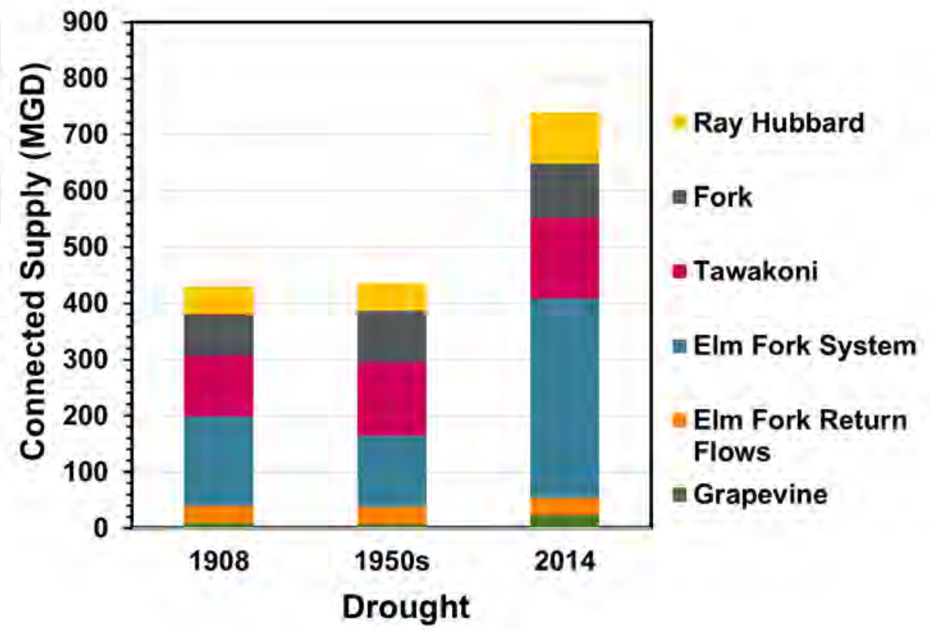
Table 5-7 and Figure 5-3 present Dallas' 2080 future reservoir supplies under firm yield operations. Similar to the 2030 conditions, the firm yield supply results show that the eastern subsystem critical drought period is the 1908 drought and west subsystem critical drought period is the 1950's drought. Similar to the 2030 supplies, the 1908 drought supply is slightly less than the 1950s drought supply for 2080 conditions when all sources are considered. However, because the 1950s drought is the most severe drought on record for Dallas' primary reservoirs (Elm Fork System and LRH), and for consistency with the Region C RWP, the 1950s drought is assumed as the drought of record for future existing supplies in the 2024 LRWSP. It should be noted that the 2024 LRWSP assumes firm yield supply impacts of LRH from sedimentation and temperature increase between 2030 and 2080 are mitigated by the additional runoff from urbanization and thus LRH firm yield supplies remain constant between 2030 and 2080.

Table 5-7. Dallas' Current Supplies (2080 Conditions)[a]

Reservoir	Supply (MGD)		
	1908 Drought	1950's Drought	Recent Drought (2010-2014)
Lake Grapevine	9.0	7.2	23.7
Elm Fork System	159.7	127.3	354.1
Additional Elm Fork System Return Flows	30.2	30.2	30.2
West Subsystem	198.9	164.7	408.0
Lake Ray Hubbard	50.3	49.7	91.9
Lake Tawakoni	107.8	130.4	143.6
Lake Fork	73.8	91.0	96.5
East Subsystem	231.9	271.1	332.0
Total System	430.8	435.8	740.0

[a] Supply estimates account for increased evaporation from an 8°F increase in temperature from the historical average due to climate change.

Figure 5-3 Dallas' Current Reservoir Supplies (2080 Conditions)



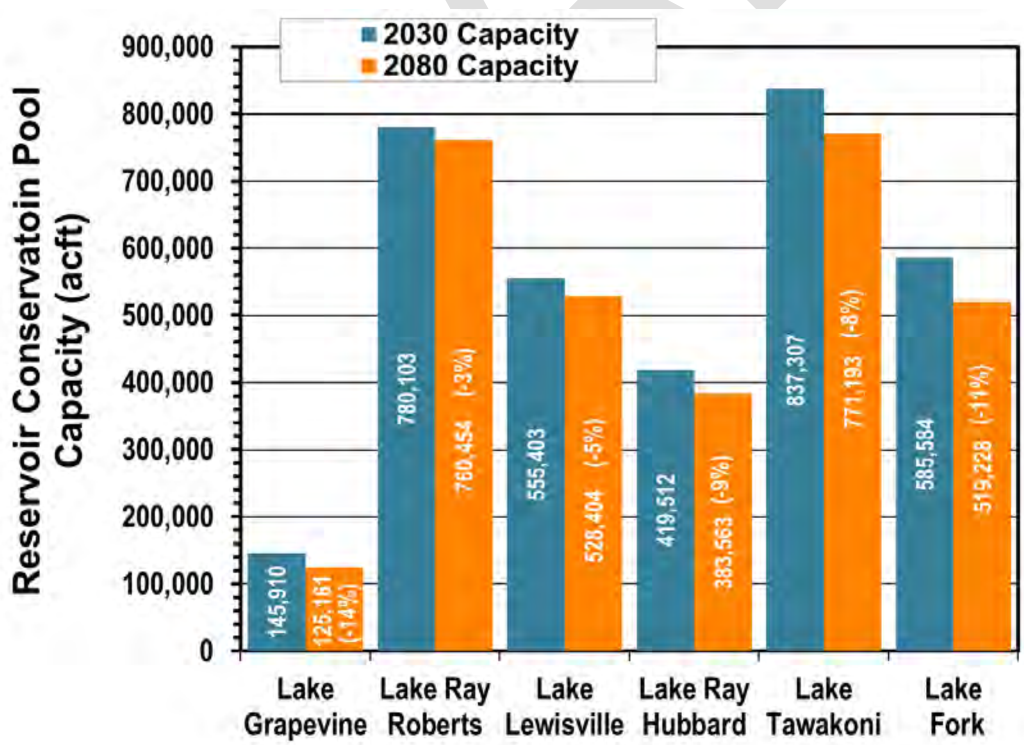
Note: 2080 supplies include temperature increase of +8 degrees F from historical averages

5.4.3 Magnitude of Supply Impacts from Potential Future Increases in Air Temperature and Sedimentation

Up until this point in the chapter, all yields presented have included the impacts of temperature increases and reservoir sedimentation. For increased temperatures, daily average high temperatures were assumed to increase by 3°F by 2030 and 8°F by 2080. This assumption was based on climate change model predictions described in Appendix I. Increased temperatures lead to increased reservoir evaporation, resulting in reduced reservoir yields. See reductions in yields reflected in the decrease in supplies between 2030 and 2080 as presented in sections 5.4.1 and 5.4.2. The supply was also reduced by the accumulation of sediment within the reservoirs over time.

For reservoir sedimentation, elevation-area-capacity tables for each reservoir were sourced from the draft 2026 RWPs for use within the Dallas RiverWare model. The elevation-area-capacity tables show the effect over time of sediment accumulation in the reservoirs. Sediment accumulation is impacted by upstream impoundments, landcover in the contributing watershed, and the frequency, duration, and intensity of inflows. Figure 5-4 shows a comparison of 2030 and 2080 conservation pool capacities (excluding dead and flood pool capacities) for Dallas' reservoirs and the percentage of capacity lost to sediment accumulation during this 50-year timeframe.

Figure 5-4. Comparison of 2030 and 2080 Reservoir Conservation Pool Capacities



To quantify which portion of the above reductions in reservoir yields are a result of potential temperature increases versus sediment accumulation, additional reservoir simulations were performed to isolate the impacts of each yield reduction factor. Figure 5-5 and Table 5-8 provide a summary of supply losses resulting from both evaporation due to potential increases in temperature from historical averages prior to 2000 and sedimentation for Dallas' reservoirs through the 50-year period from 2030 to 2080. It is estimated that approximately 29.8 MGD (33,400 acft/yr) of firm yield supply has already been lost due to the 3°F temperature increase since 2000 and resulting increase in evaporation. It is estimated that Dallas will lose an additional 51.4 MGD (57,600 acft/yr) or 11 percent of firm yield supply from 2030 to 2080 from additional evaporation due to the projected additional 5°F increase in temperature. For comparison, Dallas is anticipated to lose 13.3 MGD (14,800 acft/yr) of firm yield supply from sediment accumulation between 2030 and 2080. When the estimated yield losses from temperature increases and sedimentation are combined, it is anticipated that Dallas will lose approximately 12.9 MGD (2.6%) of its total supply per decade from these factors.

Figure 5-5. Impacts from Sedimentation & Temperature Increases to Connected Supplies (1950s Drought)

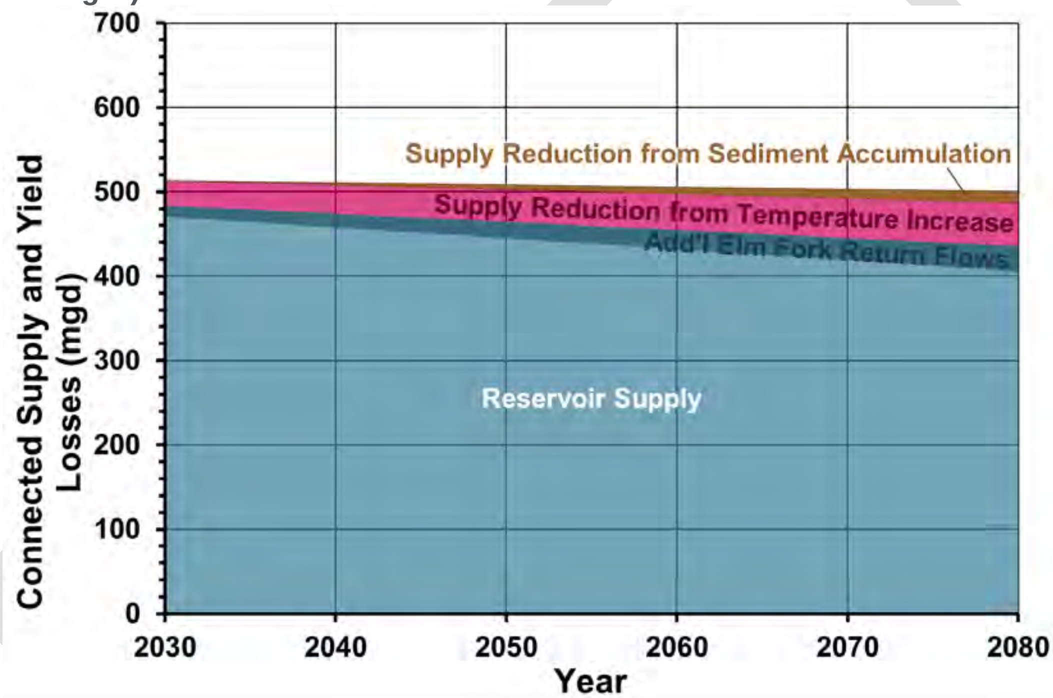


Table 5-8. Summary of Supply Impacts from Potential Increases in Evaporation and Sedimentation (1950s Drought) (MGD)

Supply Source	2030 Supply (+0°F and 2030 Sediment Conditions)	Reduction in 2030 Supply from +3°F Increase	2030 Supply (+3°F and 2030 Sediment Conditions)	Reduction in 2030 Supply from additional +5°F Increase	Reduction in 2030 Supply from Sedimentation between 2030-2080	2080 Supply (+8°F and 2080 Sediment Conditions)
Lake Grapevine	10.3	1.1	9.2	1.6	0.4	7.2
Elm Fork System	167.4	13.4	154.0	23.3	3.4	127.3
Additional Elm Form Return Flows	13.8	---	13.8	---	---	30.2
West Subsystem	**191.5**	**14.5**	**177.0**	**24.9**	**3.8**	**164.7**
Lake Ray Hubbard[a]	49.7	0.0	49.7	0.0	0.0	49.7
Lake Tawakoni	161.6	9.5	152.1	16.6	5.1	130.4
Lake Fork	111.1	5.8	105.3	9.9	4.4	91
East Subsystem	**322.4**	**15.3**	**307.1**	**26.5**	**9.5**	**271.1**
Total System	**513.9**	**29.8**	**484.1**	**51.4**	**13.3**	**435.8**

[a] Reduction in LRH supply from sedimentation and potential increases in evaporation are assumed to be mitigated with overdrafting capabilities.

5.4.4 Supply Impacts from More Severe Droughts

With climate change, more extreme weather conditions are anticipated with droughts and flood events expected to increase in intensity, duration and frequency. However, current climate models have a high level of uncertainty in the quantification of changes to the characteristics of these extreme events which present challenges in accurately quantifying their current and future impacts to the reliability of Dallas' supply sources.

To provide context for potential impacts to reliability from these extreme events, a worst-case scenario was simulated in which the 1950s drought was extended by one year for all of Dallas' supply reservoirs. While this scenario is unlikely due to the geographic diversity of Dallas' reservoirs and was not considered appropriate for use in the planning and implementation timeline of supply strategies, it does provide insight into the sensitivity of Dallas supply reliability from the duration and intensity of droughts.

The 1950s drought lasted from 1950 through 1957 when widespread rainfall ended the drought. To extend the drought by one year, instead of modeling the historical net evaporation, precipitation, and inflows in 1957 which led to recovery from the drought, a synthetic worst year was developed for 1957 which extended the 1950s drought another year.

The synthetic year (1957) of the drought was developed by repeating the most severe year on record of net evaporation and inflows across the 1907-2020 period of record for each reservoir. In addition to the worst year drought extension, climate change was accounted for by modeling a temperature increase of 3 degrees to adjust the net evaporation for simulation year 2030 and a temperature increase of 8 degrees was used to adjust the net evaporation for simulation year 2080 as described in Appendix I. Results from the analysis estimate that Dallas' total system firm yield supply would be reduced by 97.1 MGD (108,800 acft/yr) in 2080 or by 22 percent from the hypothetical drought extension. The impacts to reservoir yields from the drought extension are summarized in Figure 5-6 and Table 5-9.

Figure 5-6. Impacts from Sedimentation, Temperature Increases and Extended Drought to Connected Supplies (1950s Drought)

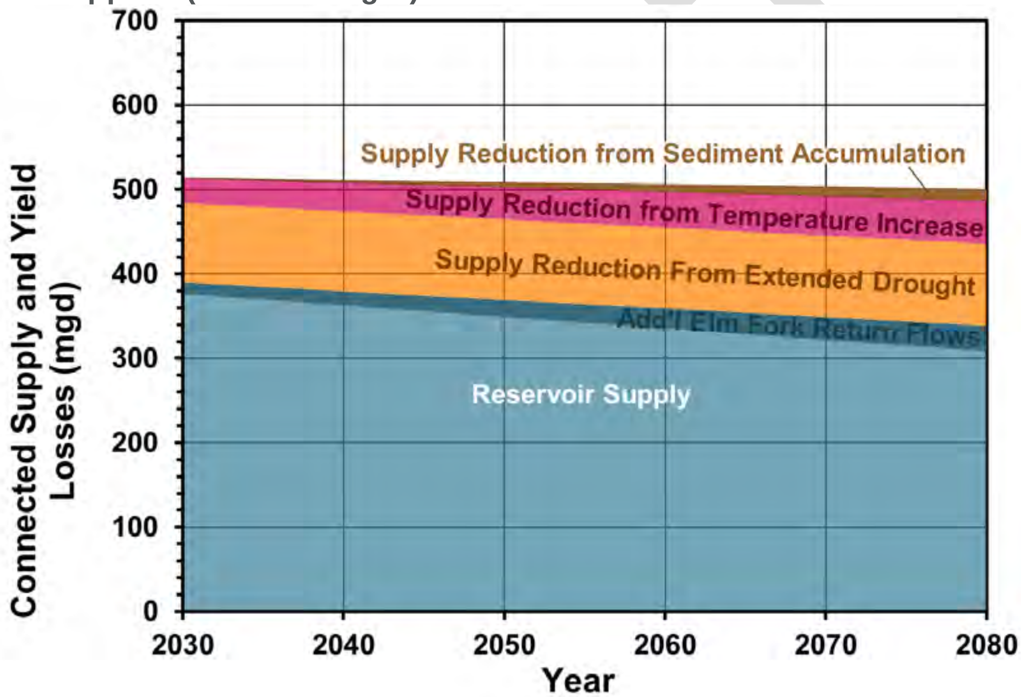


Table 5-9. Summary of Supply Impacts from Sedimentation, Temperature Increases and Extended Drought to Connected Supplies (1950s Drought) (MGD)

Supply Source	2030 Supply (+3°F and 2030 Sediment Conditions)	Reduction in 2030 Supply from Extended Drought	2030 Supply (+3°F, 2030 Sediment Conditions & Extended Drought)	2080 Supply (+8°F and 2080 Sediment Conditions)	Reduction in 2080 Supply from Extended Drought	2080 Supply (+8°F, 2080 Sediment Conditions & Extended Drought)
Lake Grapevine	9.2	2.5	6.7	7.2	2.5	4.7
Elm Fork System	154.0	36.6	117.4	127.3	37.0	90.3
Additional Elm Form Return Flows	13.8	---	13.8	30.2	---	30.2
West Subsystem	**177.0**	**39.1**	**137.9**	**164.7**	**39.5**	**125.2**
Lake Ray Hubbard[a]	49.7	0.0	49.7	49.7	0.0	49.7
Lake Tawakoni	152.1	31.0	121.1	130.4	32.0	98.4
Lake Fork	105.3	24.3	81.0	91	25.6	65.4
East Subsystem	**307.1**	**55.3**	**251.8**	**271.1**	**57.6**	**213.5**
Total System	**484.1**	**94.4**	**389.7**	**435.8**	**97.1**	**338.7**

[a] Reduction in LRH supply from sedimentation, potential increases in evaporation and an extended drought are assumed to be mitigated with overdrafting capabilities.

5.5 Unconnected Supplies

Dallas has two existing supply sources, Lake Palestine and return flows from Dallas' Central and Southside WWTPs, that are already permitted but need additional infrastructure to be connected to the Dallas system. The supplies available from these sources are provided in the following subsections. Discussion about the needed infrastructure for project implementation to use these supplies is discussed in the water management strategy section (Chapter 7).

5.5.1 Lake Palestine

Lake Palestine was simulated using the Dallas RiverWare model under current (2030) and future (2080) sediment and temperature conditions. The calculated firm yields for each of the simulated historical droughts are provided in Table 5-10.

Table 5-10. Lake Palestine Firm Yield Under Current (2030) and Future (2080) Conditions (MGD)

Drought	Current (2030) [A]	Future (2080) [B]
1908	140.8	121.2
1950's	162.9	149.6
1960's	162.4	132.3
Recent Drought (2010-2014)	149.7	129.7

[A] Current yields account for increased evaporation from a 3°F increase in temperature from the historical average due to climate change as well as 2030 sediment conditions.
[B] Future yields account for increased evaporation from an 8°F increase in temperature from the historical average due to climate change as well as 2080 sediment conditions.

Dallas is contracted with UNRMWA for the purchase of 53.73% of the annual dependable yield which was estimated to be 102 MGD (114,337 acft/yr) at the time of the execution of the contract. UNRMWA's Certificate of Adjudication No. 06-3254B also limits the amount of water diverted from Lake Palestine which can be transferred from the Neches River Basin to the Trinity River Basin for use by Dallas at 102 MGD. Based on these assumptions and the new estimates of the dependable yield, 53.73% of the firm yields will result in less than 102 MGD of supply for Dallas.

However, the February 2024 East Texas Regional Water Planning Area (Region I) Technical Memorandum estimates that only 23.8 MGD in 2030 and 32.0 MGD in 2080 of supplies from Lake Palestine will be required to meet local water use demands. It is assumed that Dallas will be able to contract for the additional unused supply from Lake Palestine up to a total supply of 102 MGD. Table 5-11 provides the estimated supply from Lake Palestine to Dallas per this assumption for each of the simulated droughts. The supply assumed to be available to Dallas from Lake Palestine once connected is based on the 1950's drought to be consistent with the drought assumed to determine Dallas' reliable connected supply. Based on this assumption, Lake Palestine supply is estimated to be 102 MGD for the 2030-2080 planning period.

Table 5-11. Dallas Portion of Lake Palestine Yield Under Current (2030) and Future (2080) Conditions (MGD)

Drought	Current (2030) [A]	Future (2080) [B]
1908	102.0	89.2
1950's	102.0	102.0
1960's	102.0	100.3
Recent Drought (2010-2014)	102.0	97.7

[A] Supply available to Dallas up to 102.0 MGD after 23.8 MGD of local needs are met. Local needs obtained from **February 2024 East Texas Regional Water Planning Area (Region I) Technical Memorandum**.
[B] Supply available to Dallas up to 102.0 MGD after 32.0 MGD of local needs are met. Local needs obtained from February 2024 East Texas Regional Water Planning Area (Region I) Technical Memorandum.

5.5.2 Dallas Wastewater Effluent Projections: Central and Southside Wastewater Treatment Plants

Dallas treats wastewater from its retail customers and customer cities that send wastewater to the Central and Southside WWTPs. The treated wastewater effluent discharged into the Trinity River from Dallas' Central and Southside WWTPs is an unconnected supply source and is downstream of Dallas' supply reservoirs and run-of-river diversion locations on the Elm Fork of the Trinity River. Dallas currently owns Water Use Permit 12468 for the conveyance and use of up to 220.7 MGD (247,200 acft/yr) of return flows from Central and Southside WWTPs subject to certain special conditions and environmental flow requirements; however, no infrastructure currently exists to deliver this supply to Dallas' treatment and distribution system.

Treated effluent projections for the 2030-2045 period were obtained from Table 2-11 Total DWU Treated Flow Projections in the 2024 update of the *DWU 2020 Wastewater Facilities and Operations Strategic Plan* (WFOSP). Effluent projections were extended to 2080 using the average wastewater GPCD from the updated WFOSP found in section 2.5.2 Flow Projections on page 2-53 of the WFOSP. A wastewater GPCD of 148 was applied to the DWU wastewater service area projected population.

The DWU wastewater service area population from the updated WFOSP utilized data from the North Central Texas Council of Governments (NCTCOG). It is important to note that Dallas' wastewater service area is different than the treated and raw water service area. The NCTCOG projected population growth in the DWU wastewater service area linearly at a rate of roughly 14,000 individuals per year. The WFOSP used these populations to project outwards to 2045. The 2024 LRWSP this same growth rate to extend the WFOSP projections to 2080.

Average condition treated wastewater effluent is expected to increase from 216 MGD in 2030 to 316 MGD in 2080. In dry conditions, projected effluent is expected to increase from 182 MGD in 2030 to 267 MGD in 2080. Wet conditions projected effluent is expected to increase from 245 MGD in 2030 to 359 MGD in 2080. Projected flowrates for combined treated effluent from Dallas' Central and Southside WWTPs are shown in Table 5-12 and in Figure 5-7. Historical combined wastewater effluent is also provided in the figure for comparison.

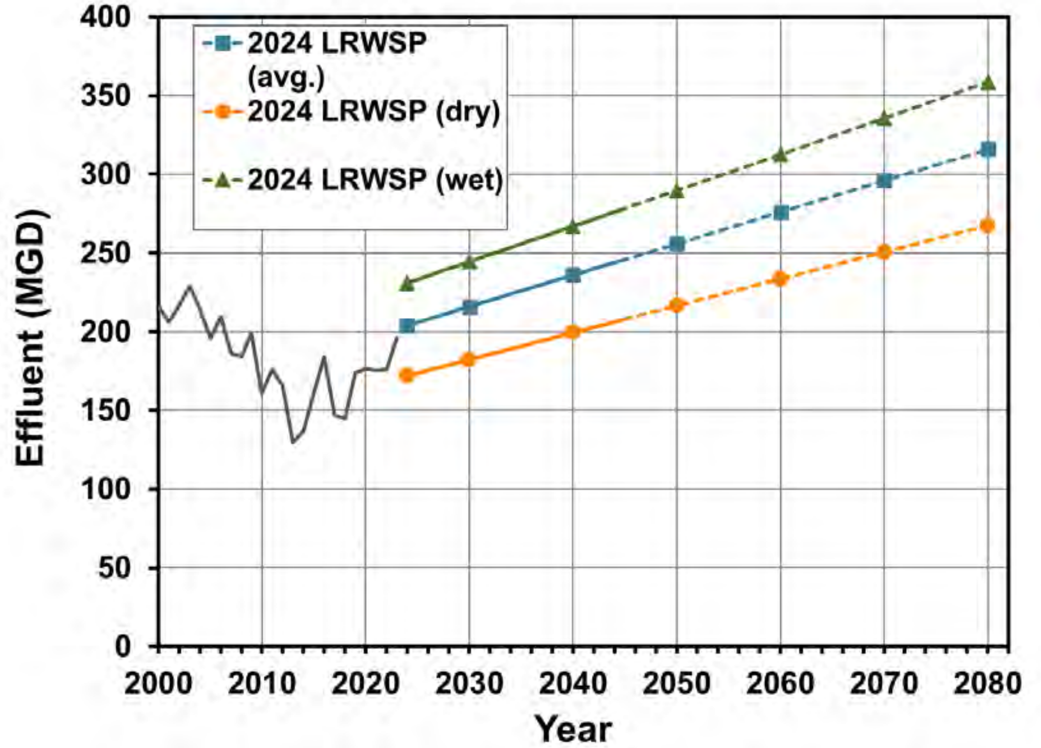
Table 5-12. Projected Wastewater Effluent from Dallas Central and Southside Wastewater Treatment Plants

Table units: MGD

Projection	2030	2040	2050	2060	2070	2080
2024 LRWSP (avg.)	216	236	256	276	296	316
2024 LRWSP (dry)	182	199	216	233	250	267
2024 LRWSP (wet)	245	267	290	313	336	359

Note: Projections for 2024-2045 were obtained from DWU 2024 Wastewater Facilities and Operations Strategic Plan. Projections were extended to 2080 using population estimates and GPCD from the 2024 "Historical and Future Demand Projections" update to DWU's Wastewater Facilities and Operations Strategic Plan.

Figure 5-7. Projected Wastewater Effluent from Dallas Central and Southside Wastewater Treatment Plants



This Page Intentionally Blank.

6 Water Supply Needs and Plan

This section presents DWU's future water supply needs resulting from growth in population and water demands with consideration of predicted reductions in connected supplies. The first part of this section summarizes the future water needs for DWU considering the findings of the previous sections. The second part of this section provides the recommended plan for DWU to meet these future needs through the 2080 planning horizon.

6.1 Water Supply Needs

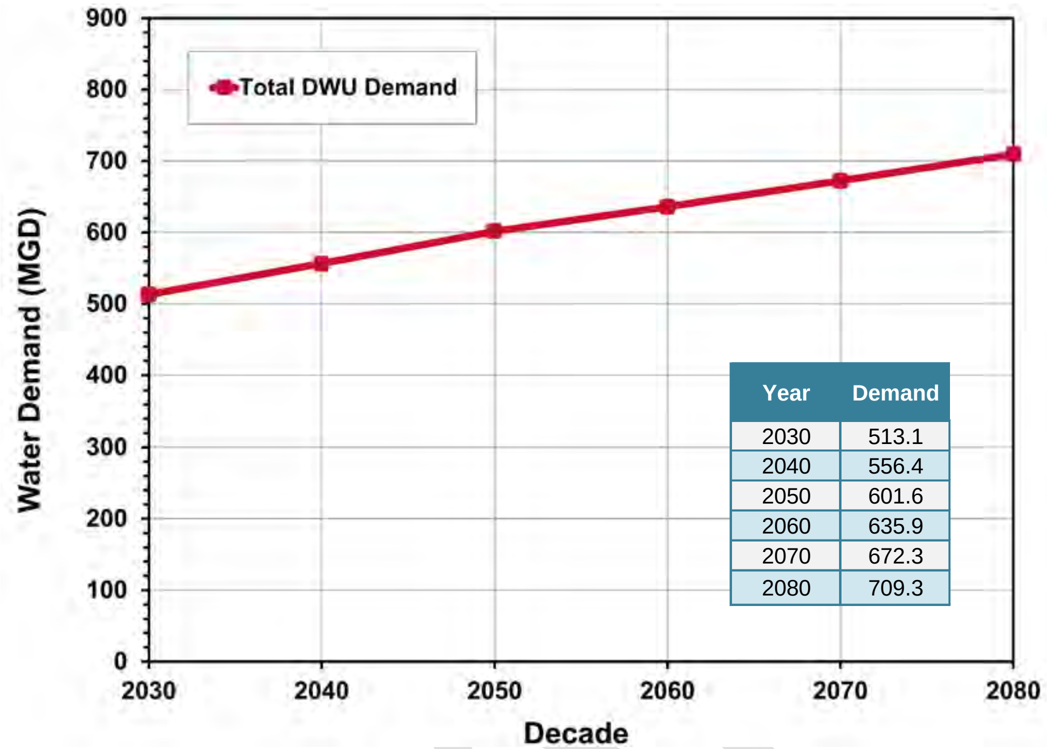
DWU's water supply need is the difference between projected future demand and available connected supply. When the demand is greater than the available supply, the difference is referred to as a deficit. When the available supply is greater than the demand, the difference is referred to as a buffer. DWU's future demands are projected to increase as a result of population growth, while DWU's current supplies are projected to decrease as a result of reservoir sedimentation and increased evaporation from predicted increases in air temperature. This results in a supply deficit, as demands overtake connected supplies. Additional supply will need to be added through the recommended water supply strategies in order to overcome the supply deficit and provide a sufficient buffer.

Figure 6-1 shows the estimated total raw water demand for the DWU system through 2080, as shown in Table 6-1 and discussed in Chapter 4. The demand is the total water needed at DWU's treatment plants for City of Dallas Retail and DWU Customer Cities that purchase treated water plus the demand of the Customer Cities that purchase untreated water from DWU. These demands represent drought or dry year demands as described in Chapter 4.

Figure 6-2 shows the total existing connected supply available from Dallas' reservoirs through 2080 as shown in Chapter 5. The connected supplies include future reductions due to consideration of reservoir sedimentation and increased evaporation from predicted increases in air temperature, based on 1950's drought conditions. The connected supplies are based on firm yield estimates of the reservoirs and DWU's contracted or agreed volume. The connected supplies include predicted growth in return flows that are available for diversion by DWU as estimated and discussed in Chapter 5.

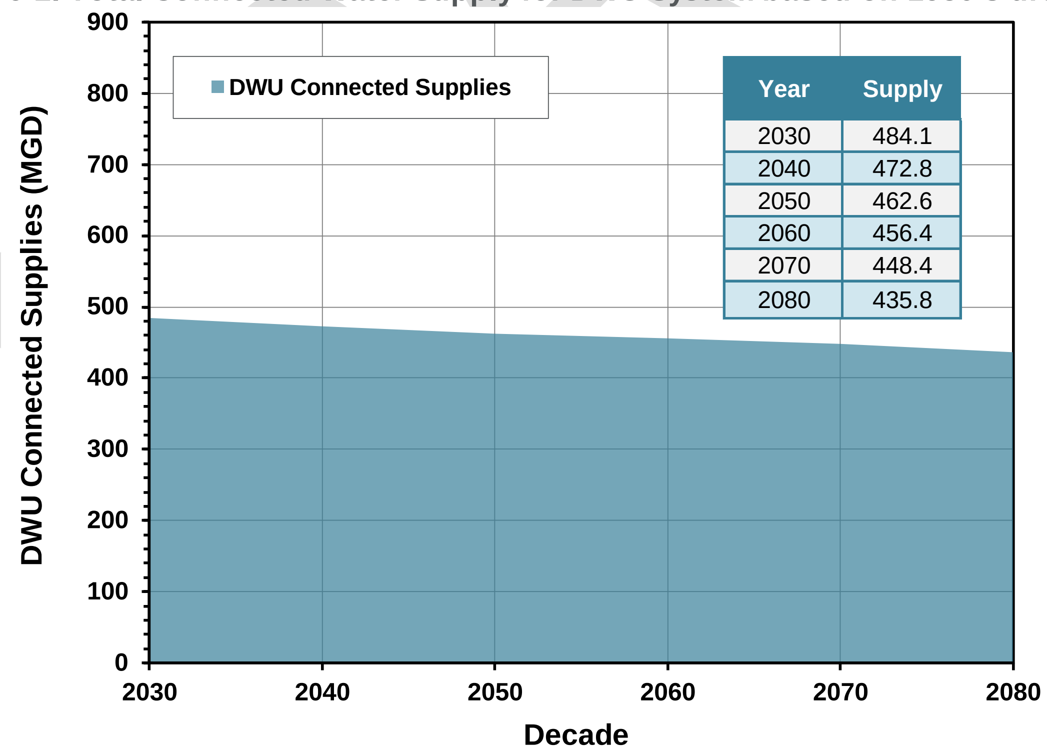
Figure 6-3 presents the combined data from Figure 6-1 and Figure 6-2 and shows when the demand is projected to overtake the connected supply resulting in a supply deficit. The figure shows that by 2030 DWU will have a supply deficit of 28.5 MGD and by 2080, the supply deficit will be 272.9 MGD. Due to the projected population and demand growth, and rate of declining connected supplies, DWU's supply deficit begins to occur before the 2030 decade.

Figure 6-1. Total Water Demand for DWU System



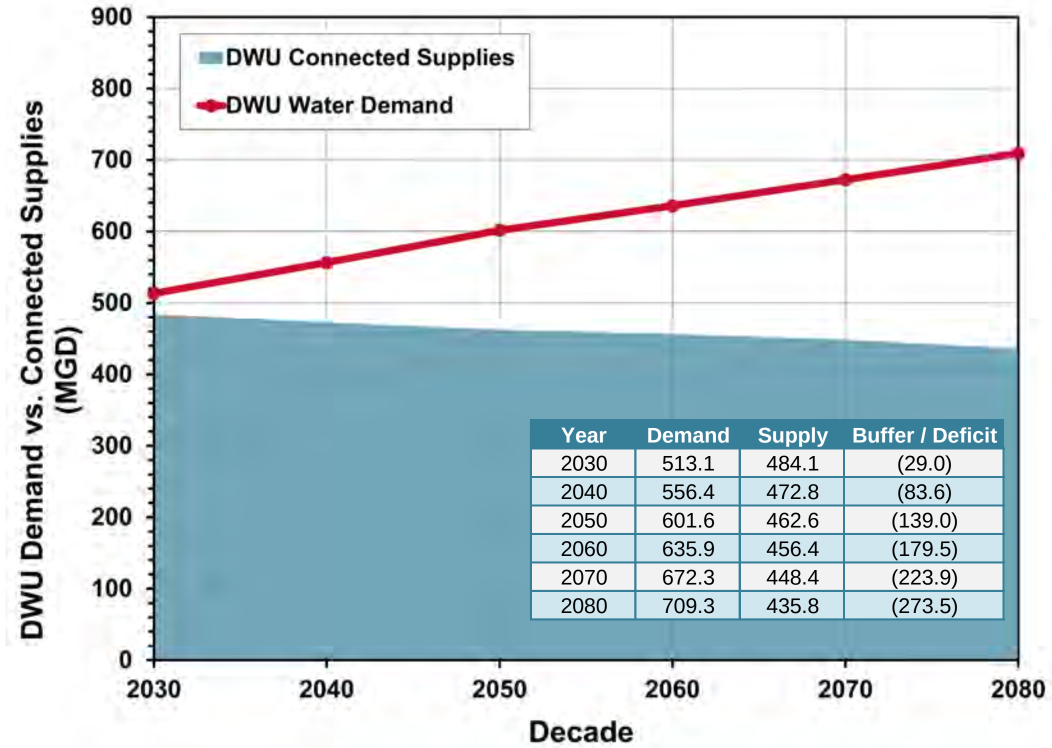
Year	Demand
2030	513.1
2040	556.4
2050	601.6
2060	635.9
2070	672.3
2080	709.3

Figure 6-2. Total Connected Water Supply for DWU System based on 1950's drought



Year	Supply
2030	484.1
2040	472.8
2050	462.6
2060	456.4
2070	448.4
2080	435.8

Figure 6-3. Comparison of Water Demand and Connected Supply for DWU System



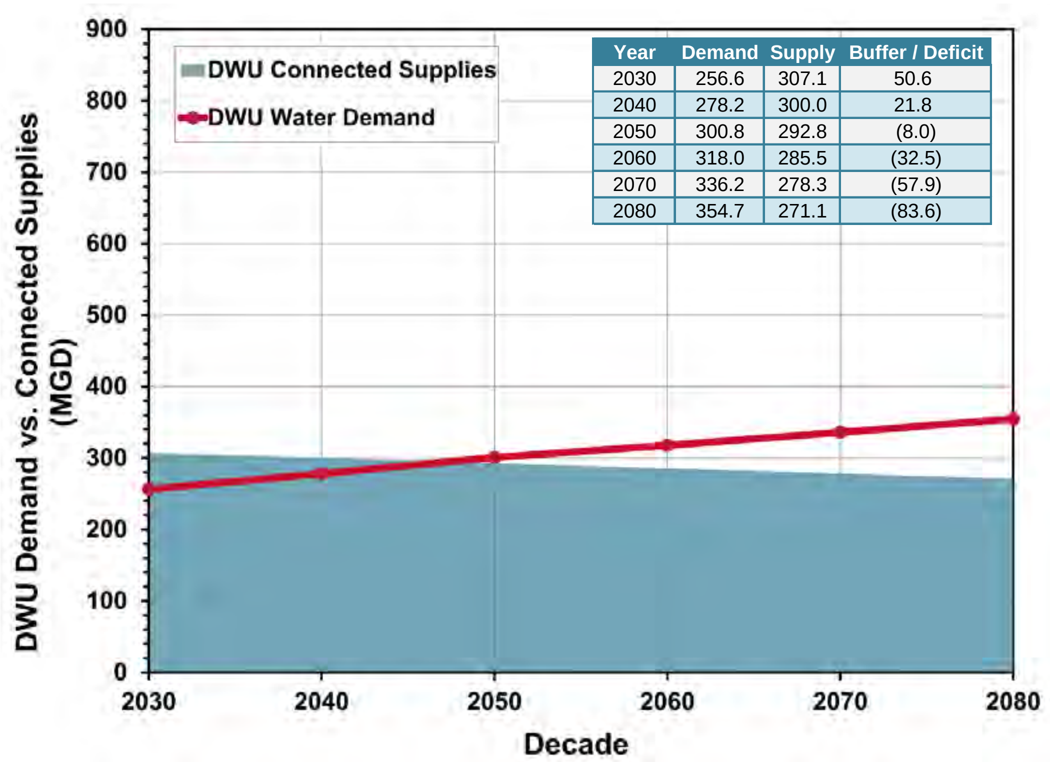
Year	Demand	Supply	Buffer / Deficit
2030	513.1	484.1	(29.0)
2040	556.4	472.8	(83.6)
2050	601.6	462.6	(139.0)
2060	635.9	456.4	(179.5)
2070	672.3	448.4	(223.9)
2080	709.3	435.8	(273.5)

For the purposes of planning and throughout this report, the DWU water supply system is described as consisting of two subsystems – an eastern subsystem and a western subsystem. Each subsystem is supplied by its own set of supply reservoirs. It is understood that demand can vary between these two subsystems, but for this analysis and planning purposes, the demand is split 50 percent to the east, and 50 percent to the west. Analyzing the two subsystems with a 50 percent demand split is consistent with the 2014 LRWSP. Since the supplies available from the reservoirs that supply each subsystem are not split evenly, consequently neither are the resulting needs. In practice, the distribution system is not isolated based on treatment plant or specific supply.

6.1.1 Eastern Subsystem Needs

The eastern subsystem is supplied from three reservoirs: Lake Ray Hubbard, Lake Tawakoni, and Lake Fork. These three reservoirs all deliver water to the Eastside WTP. Figure 6-4 shows a comparison of the connected supply for the eastern subsystem with 50 percent of the demands. In 2030 the eastern subsystem is estimated to have a buffer of 50.8 MGD. By 2080, the eastern subsystem is expected to have a deficit of 83.3 MGD. A supply deficit for the eastern subsystem is estimated to occur around 2047.

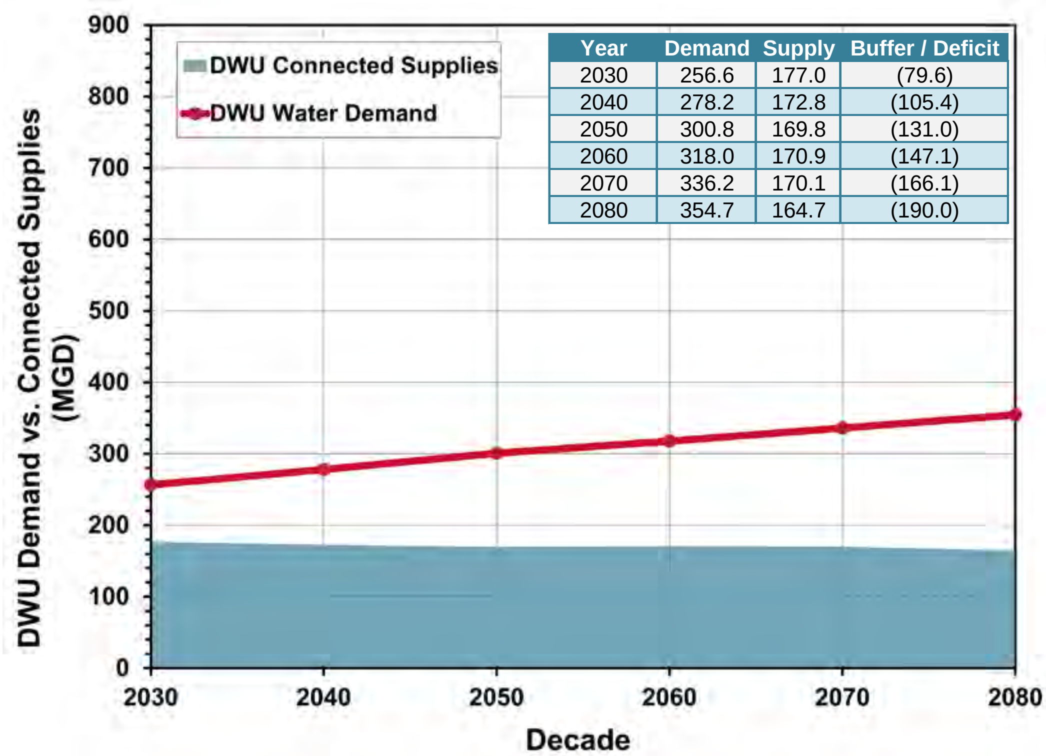
Figure 6-4. Comparison of Water Demand and Supply for DWU's Eastern Subsystem



6.1.2 Western Subsystem Needs

The western subsystem is supplied from Lake Grapevine and the Elm Fork System which is made up of Lake Lewisville, Lake Ray Roberts, and the Elm Fork run of river rights. All water supplies are delivered to the Elm Fork WTP and Bachman WTP. Figure 6-5 shows a comparison of the connected supply for the western subsystem with 50 percent of the demands. In 2030 the western subsystem is estimated to have a deficit of 79.3 MGD. By 2080, the western subsystem is expected to have a deficit of 189.7 MGD. The western subsystem shows as currently experiencing a supply deficit, however, as mentioned above, in practice, the distribution system is not isolated based on treatment plant or specific supply. It is important to note that DWU's western supplies are not predicted to experience as significant of a reduction over time due to the increase in return flows estimated to be available to DWU.

Figure 6-5. Comparison of Water Demand and Supply for DWU's Western Subsystem



Year	Demand	Supply	Buffer / Deficit
2030	256.6	177.0	(79.6)
2040	278.2	172.8	(105.4)
2050	300.8	169.8	(131.0)
2060	318.0	170.9	(147.1)
2070	336.2	170.1	(166.1)
2080	354.7	164.7	(190.0)

6.1.3 Water Supply Needs – Summary of Findings

The DWU water supply system is estimated to need additional supplies connected prior to 2030. When considering DWU's two subsystems separately, the need for additional supply occurs prior to 2030 for the western subsystem. DWU has the operational flexibility within its distribution system to shift supplies between two subsystems to as much as a 45/55 percent split. DWU can temporarily use this operational flexibility to shift a portion of the western subsystem demand deficit to the eastern subsystem where there is a supply buffer.

The following list summarizes the key finding from the 2024 LRWSP regarding DWU's future water supply needs. This list highlights significant findings that were considered during the process of selecting the recommended strategies for DWU to implement to meet the needs of the DWU water supply system for the 50-year planning horizon.

- The DWU water supply system is comprised of two subsystems.
  - The DWU eastern subsystem includes Lake Ray Hubbard, Lake Tawakoni, and Lake Fork – all of which deliver water to the Eastside WTP.
  - The DWU western subsystem includes Lake Ray Roberts, Lake Lewisville, Lake Grapevine, and run of the river rights – all of which deliver water to the Bachman Water Treatment Plant and Elm Fork Water Treatment Plant.

- DWU needs additional connected supply prior to 2030 in order to meet customer demands, accommodate for potential drought demands, and maintain an overall system supply buffer. However, DWU needs additional supply on the western subsystem sooner than the eastern subsystem.

With consideration of the above findings, Table 6-1 presents DWU demand, connected supply, and need information for its western and eastern subsystem, and total system.

Table 6-1. Summary of Demands, Supplies, and Needs for DWU Total System and Subsystems

Table units: MGD

Supplies and Demand	2030	2040	2050	2060	2070	2080
Western Subsystem						
Lake Grapevine Supply	9.2	8.8	8.4	8.0	7.6	7.2
Elm Fork System Supply (Lake Ray Roberts & Lake Lewisville)	154.0	148.6	143.3	138.0	132.7	127.3
Elm Fork Return Flows [a]	13.8	15.4	18.1	24.9	29.8	30.2
Western Subsystem Supply Total	177.0	172.8	169.8	170.9	170.1	164.7
50% Demand	256.6	278.2	300.8	318.0	336.2	354.7
Buffer / (Deficit)	(79.6)	(105.4)	(131.0)	(147.1)	(166.1)	(190.0)
Eastern Subsystem						
Lake Ray Hubbard Supply	49.7	49.7	49.7	49.7	49.7	49.7
Lake Tawakoni Supply	152.1	147.8	143.5	139.1	134.8	130.4
Lake Fork Supply	105.3	102.5	99.6	96.7	93.8	91.0
Eastern Subsystem Supply Total [b]	307.1	300.0	292.8	285.5	278.3	271.1
50% Demand	256.6	278.2	300.8	318.0	336.2	354.7
Buffer / (Deficit)	50.6	21.8	(8.0)	(32.5)	(57.9)	(83.6)
Total System						
Total Supply	**484.1**	**472.8**	**462.6**	**456.4**	**448.4**	**435.8**
Total Demand	**513.1**	**556.4**	**601.6**	**635.9**	**672.3**	**709.3**
Buffer / (Deficit)	**(29.0)**	**(83.6)**	**(139.0)**	**(179.5)**	**(223.9)**	**(273.5)**

[a] Includes increases in return flows available to DWU in the Elm Fork System above the amount of return flows included in DWU's Water Supply model that are already included in the yield numbers, discussed in Section 5.

[b] This value assumes that the 144" transmission line from Lake Tawakoni to the Eastside WTP is in place allowing for full utilization of these supplies. This transmission line is not currently built but is included in the City of Dallas CIP for construction by 2030.

6.2 Dallas Water Supply Plan

The main goals of the 2024 LRWSP include developing a thorough City of Dallas Retail population projection and a Retail demand projection that accurately reflects the growth expected, the potential demand that could result from extended drought, and updating DWU Customer Cities demands using the latest Region C data. By identifying the expected population growth and demands, the 2024 LRWSP reevaluates the previously recommended and alternative strategies developed in the 2014 LRWSP as well as a select number of new strategies. The 2014 LRWSP utilized a rigorous process to identify and evaluate strategies that could potentially meet DWU's needs while minimizing costs and environmental impacts. The 2024 LRWSP builds upon this foundation and examines previously recommended and alternative strategies for viability and selection to be included in the 2024 LRWSP. As seen in Table 6-1, DWU needs 273.5 MGD of additional supply by 2080 to overcome the projected supply deficit from the combination of population growth, drought conditions, and existing connected supply reductions. Reevaluating these strategies will help build on DWU's current plan and the steps DWU is currently taking to secure additional water supply.

All strategies from the 2014 LRWSP were reevaluated for the 2024 LRWSP. The existing and new strategies, shown in Table 6-2, were evaluated with respect to cost, supply quantity, potential environmental concerns, feasibility, and equity. The recommended strategies are the most favorable of the strategies evaluated for the 2024 LRWSP and are the strategies that DWU intends to implement to meet its needs. The remaining strategies are referred to as alternative strategies and have been identified to replace recommended strategies in the event that one or more recommended strategies were to become infeasible. Four of the strategies evaluated for the 2024 LRWSP were not designated as recommended or alternative and are discussed further in Chapter 7. In the RWP process, alternative strategies can be used to replace recommended strategies if implementation plans for recommended strategies change over time.

Table 6-2 Strategies Evaluated for the 2024 LRWSP

Table units: MGD, September 2023 dollars

Strategies Evaluated for 2024 LRWSP	Projected Supply (MGD)	Unit Cost ($/1,000 gal)
Additional Conservation	60.5	$0.43
Main Stem Pump Station - NTMWD Swap Agreement	44.2	N/A [a]
Main Stem Balancing Reservoir	102	$3.71
IPL Connection to the DWU System	102	$1.21
Neches Run-of-River	48	$3.96
Lake Columbia	50	$3.30
Direct Reuse	2.23	$3.75
Sabine Conjunctive Use		
Part 1 - Carrizo-Wilcox Groundwater	27	$6.05
Part 2 – Sabine River Off-Channel Reservoir	66	$3.08
Red River OCR	82.4	$5.75
Sulphur Basin Project	-	-
High Yield	71.2	$6.25
Low Yield	62.7	$6.64
Toledo Bend Reservoir to Dallas West System	89	$6.48
Lake Texoma Desalination	130	$9.06
Interstate - Kiamichi River	268	$3.69
Interstate - Little River-Millwood Lake	268	$6.29
Interstate - Toledo Bend SRA LA	179	$9.57
Aquifer Storage & Recovery – Resiliency [b]	N/A	N/A
Stormwater Supplies [b]	N/A	N/A
Riverbank Filtration [b]	N/A	N/A

[a] Unit cost not included because project infrastructure has already been built.

[b] Supply and costs not developed for these strategies, as indicated by 'N/A', due to conclusion of the completed analysis. Evaluation discussed further in Chapter 7.

6.2.1 Previously Recommended and Alternative Strategies

The 2014 LRWSP produced 14 strategies, seven of which were recommended and seven that were designated as alternative strategies. DWU is working towards implementation of two of the recommended strategies: Main Stem Pump Station and Lake Palestine Integrated Pipeline project (IPL). These two strategies are not connected to the DWU system yet and therefore were still evaluated for the 2024 LRWSP. A summary of the 2014 LRWSP recommended and alternative strategies is shown in Table 6-3. The projected supply volumes shown were the anticipated supply volumes at the time of the evaluation and the unit costs are in September 2013 dollars.

Table 6-3. 2014 LRWSP Strategies for DWU

Table units: MGD, September 2013 dollars

2014 LRWSP Strategies	Projected Supply (MGD)	Unit Cost ($/1,000 gal)
2014 Recommended Strategies		
Additional Conservation (Dallas)	46.4	$0.38
Indirect Reuse - Main Stem Pump Station (NTMWD swap agreement)	31.1	$0.25
Indirect Reuse - Main Stem Balancing Reservoir	102	$1.74
Connect Lake Palestine	102	-
IPL Part 1 - Connection to Lake Palestine	-	$2.31
IPL Part 2 - Connection to Bachman WTP	-	$0.49
Neches Run-of-River	42.2	$1.88
Lake Columbia	50	$1.78
2014 Alternative Strategies		
Direct Reuse - Alternative 1	2.23	$2.43
Carrizo-Wilcox Groundwater (Alternative 2)	26.7	$1.80
Sabine - Conjunctive Use (OCR and groundwater)	93	$2.27
Red River OCR	102	$2.27
Sulphur Basin Project - Wright Patman (232.5) / Marvin Nichols (296.5)	102	$2.28
Toledo Bend Reservoir	179	$3.14
Lake Texoma Desalination	130	$3.54

6.2.2 Recommended Strategies for the 2024 LRWSP

Recommended strategies are strategies that DWU will actively pursue and implement to meet the needs identified in the 2024 LRWSP. The recommended water supply strategies are listed in Table 6-4. Figure 6-6 provides a breakdown of the projected supply from the recommended strategies by type.

Figure 6-7 shows the location of these recommended strategies. Note that part of the Lake Palestine Integrated Pipeline project (IPL) is shared with TRWD and is under construction. The IPL project blends DWU and TRWD supplies in the joint pipeline before delivering the supplies to DWU and TRWD. TRWD only segments of the pipeline are not shown. The IPL project and Main Stem Pump Station project are two recommended strategies that DWU is actively working to implement but are not yet connected to the system, and therefore remain recommended strategies. A brief description of each recommended strategy is presented in the following subsections. Chapter 7 provides a detailed evaluation of the recommended and alternative strategies.

Table 6-4. Recommended Strategies for DWU

Recommended Strategies	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Additional Conservation	60.5	$391 [a]	$0.43
Main Stem Pump Station - NTMWD Swap Agreement	44.2	N/A [b]	N/A [b]
IPL Connection to the DWU System	102	$587	$1.21
Neches River Basin Supply	-	-	-
Neches Run-of-River	48	$719	$3.96
Lake Columbia	50	$685	$3.30
Sabine Conjunctive Use			
Part 1 – Carrizo-Wilcox Groundwater	27	$695	$6.05
Part 2 – Sabine River Off-Channel Reservoir	66	$903	$3.08
Main Stem Balancing Reservoir	102	$1,767	$3.71

[a] Equivalent total project cost based on net present value analysis for the 50-year planning horizon. See Chapter 7 for detail.
[b] Project cost and unit cost not included because project infrastructure has already been built.

Figure 6-6. Comparison of Recommended Strategies by Type

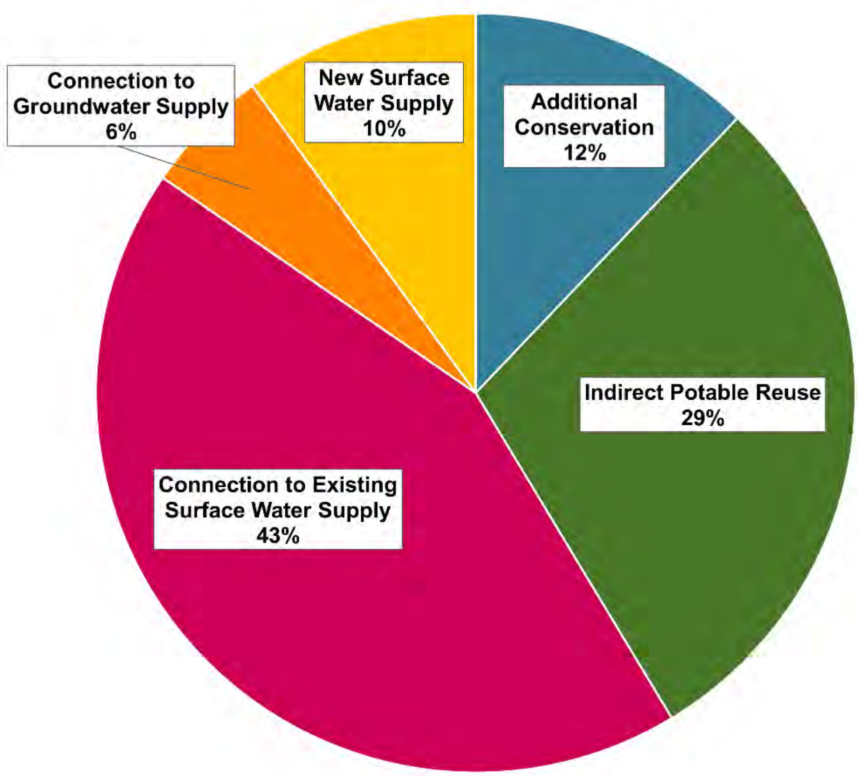
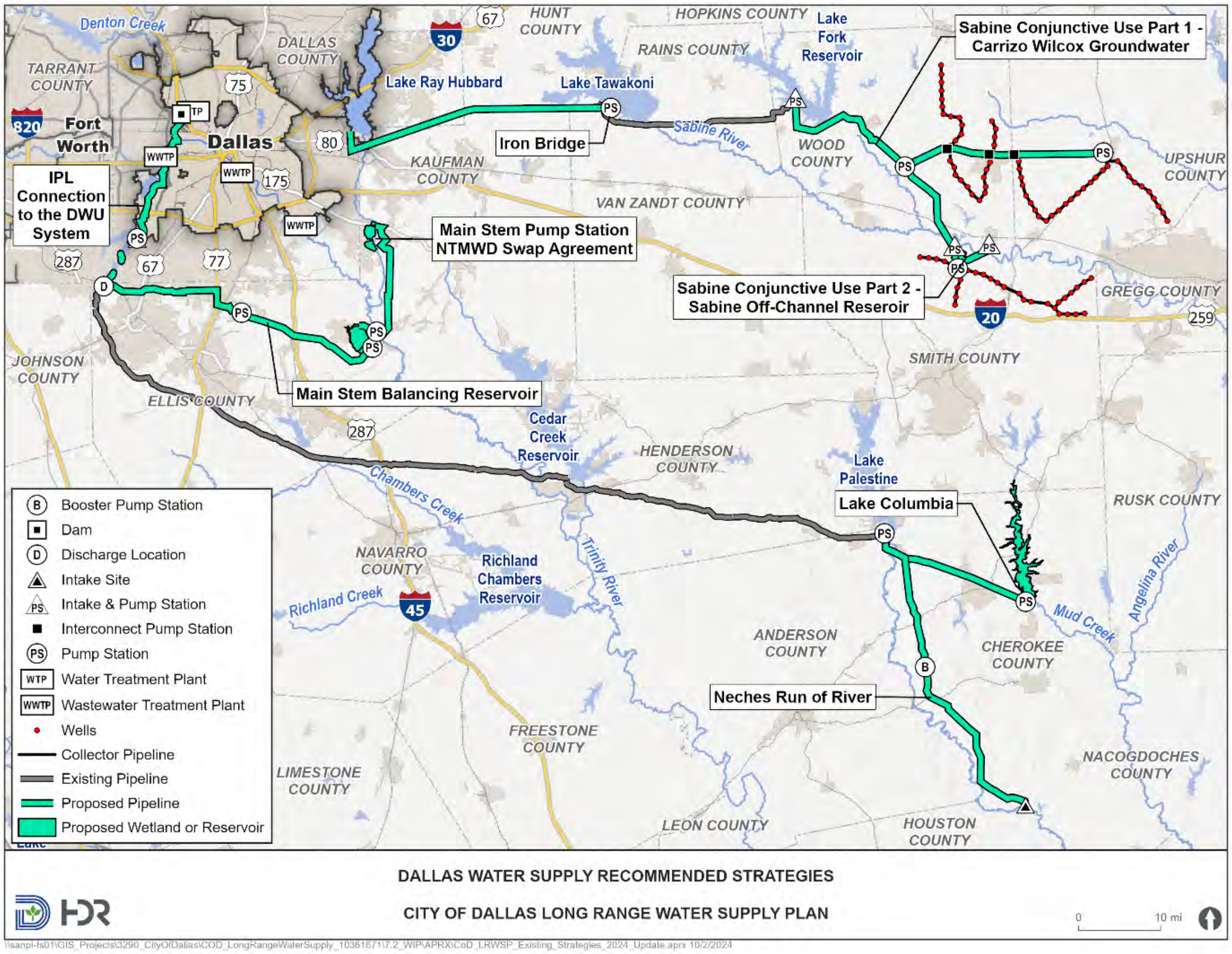


Figure 6-7. DWU System with Recommended Strategies



6.2.2.1 ADDITIONAL CONSERVATION

Additional conservation is one of the most efficient strategies to meet DWU's future needs. This strategy encompasses many different measures but mainly consists of actions by DWU and its retail customers to reduce water use as well as actions to reduce or eliminate losses throughout the distribution system. Additional conservation is currently being implemented by DWU as evident by DWU's recent update to its water conservation plan and efforts to develop a conservation plan that incorporates existing conservation measures with new measures to maximize water savings and demand reduction. The recommended conservation efforts and policies are expected to reduce demands for a maximum savings of 60.5 MGD throughout the 50-year planning period.

6.2.2.2 MAIN STEM PUMP STATION – NTMWD SWAP AGREEMENT

In 2008, Dallas entered into an agreement with the North Texas Municipal Water District (NTMWD) to swap a portion of DWU's effluent in the Trinity River discharged from the Central and Southside WWTPs for discharges of NTMWD effluent into Lake Ray Hubbard and some into the upper Trinity Basin. The volume of supply associated with the swap is approximately 39.0 MGD in 2030 and increases to 44.2 MGD in 2080. The swap allows DWU to impound NTMWD effluent in its own lakes, in lieu of releasing this water downstream for subsequent diversion by NTMWD at its East Fork of the Trinity (East Fork) wetlands project. The Main Stem Pump Station has been constructed at a location below the confluence of the East Fork and the main stem of the Trinity River and will divert a portion of DWU's return flows from the Central and Southside WWTPs to NTMWD's East Fork wetlands project. The pump station and pipeline required for this strategy has been constructed. The remaining project component required for full implementation is the finalization of the swap agreement between Dallas and NTMWD.

6.2.2.3 IPL CONNECTION TO THE DWU SYSTEM

Lake Palestine is owned and operated by the Upper Neches River Municipal Water Authority (UNRMWA). Dallas is contracted with the UNRMWA for 53.73 percent of the yield of Lake Palestine up to a maximum of 102 MGD, whichever is less.

Dallas has entered into an agreement with the Tarrant Regional Water District (TRWD) to partner in a large raw water transmission line known as the integrated pipeline (IPL). The IPL is a joint effort to bring Lake Palestine water to DWU, and additionally bring Richland Chambers and Cedar Creek Reservoir supplies to TRWD. DWU has a 150 MGD capacity share in this pipeline. Construction of the joint segment of this pipeline is underway. DWU's portion of this project includes an intake in Lake Palestine, transmission pipeline to connect to the IPL, and a share of the cost of the joint segment of the IPL pipeline.

The segment of the IPL known as the Bachman turnout is the location where Dallas' portion of the supplies from the IPL will be split off and brought into the DWU system, as currently planned. This portion of the project is currently being reevaluated for the recommended route to connect to the DWU system with one connection at the Bachman WTP and another at a yet to be determined site in a southern pressure zone The costs shown for this portion of the project are updated estimates based on a delivery option to the Bachman Water Treatment Plant but are subject to change pending further evaluation of an alternative, such as a fourth WTP.

6.2.2.4 NECHES RIVER BASIN SUPPLY

Two recommended water supply strategies have been identified in the Neches River Basin – Neches run-of-river and Lake Columbia. Project configuration of these strategies both rely on the transmission of the strategy supply to the IPL pump station and then using the IPL pipeline to connect the supply to DWU. Due to IPL pipeline capacity being limited to 150 MGD, only one of the Neches River Basin Supply strategies will be implemented. Further evaluation will be needed to decide which of these strategies to implement.

6.2.2.4.1 NECHES RUN-OF-RIVER

Dallas has been coordinating with the Upper Neches River Municipal Water Authority (UNRMWA) to review development of additional supplies in the Neches River Basin. A run-of-river diversion option was identified where unappropriated water is diverted from the Neches River at a location downstream of Lake Palestine and pumped back to Lake Palestine for delivery to DWU through the IPL pump station and pipeline. This strategy is estimated to supply 48 MGD, limited by capacity in the IPL pipeline.

6.2.2.4.2 LAKE COLUMBIA

The Angelina Neches River Authority (ANRA) has been pursuing the permitting of the Lake Columbia project to meet local needs in the Neches River Basin and provide supply to other entities in the region, such as Dallas. The supply available to Dallas from the project is estimated to be approximately 50 MGD after consideration of local needs and IPL capacity. This supply would require the permitting and construction of a new reservoir on Mud Creek and transmission facilities from the new reservoir to Lake Palestine for delivery to the DWU system through the IPL pump station and pipeline.

6.2.2.5 SABINE CONJUNCTIVE USE

The recommended Sabine Conjunctive Use strategy involving Carrizo-Wilcox groundwater and an off-channel reservoir near the Sabine River is intended to be implemented in phases to better align with DWU's needs. Part one will be the development of groundwater in the Carrizo-Wilcox and Queen City aquifers. Part two will be the development of the off-channel reservoir to impound surface water diverted from the Sabine River.

6.2.2.5.1 PART 1 – CARRIZO-WILCOX GROUNDWATER

DWU first intendeds to develop groundwater in the Carrizo-Wilcox and Queen City aquifers in Wood, Upshur, and Smith counties to meet DWU system needs. The supply available to DWU from this strategy with 110 wells is projected to be 27 MGD. This strategy would require the purchase of land or lease agreements to access the groundwater and transmission facilities from the well fields to the existing pump station at Lake Fork Reservoir for delivery to the DWU system through the existing pipeline.

6.2.2.5.2 PART 2 – SABINE OFF-CHANNEL RESERVOIR

Part 2 of this strategy would incorporate an off-channel reservoir to divert surface water from the Sabine River and supply approximately 60 MGD. The OCR would then become the primary supply source for this project and the groundwater developed in Part 1 would be used to support the surface water supplies. Once Part 2 of the Sabine Conjunctive Use strategy is in place and both components are operating as a system, the combined, conjunctive yield increases to a total of 93 MGD. Water from the OCR will be delivered to the Lake Fork Reservoir pump station in the same pipeline as the groundwater, and from there, the OCR and groundwater supply will be delivered through an existing pipeline to the DWU system.

6.2.2.6 MAIN STEM BALANCING RESERVOIR

Dallas has a water rights permit to divert and use its effluent discharged from its Central and Southside WWTPs. This strategy involves building a large storage reservoir (about 300,000-acre feet) below the confluence of the East Fork and the main stem of the

Trinity River to store DWU's return flows which would provide both storage and natural treatment until it is needed for supply. The water diverted into the off-channel storage reservoir (OCR) would be delivered back to one of DWU's WTPs or swapped with another entity for an alternative supply. DWU anticipates the supply from the Main Stem Balancing Reservoir to be as much as 102 MGD by 2080

6.2.3 Alternative Strategies for the 2024 LRWSP

The 2024 LRWSP includes a group of alternative strategies that were identified from the list of 2024 LRWSP evaluated strategies. Alternative strategies are strategies that could be developed in the event one or more of the recommended strategies encountered an implementation obstacle that renders the strategy infeasible. It is recommended that DWU continue to evaluate these strategies, along with the implementation of recommended strategies, to be in the position to designate an alternative strategy as a recommended strategy if the need arises. The alternative strategies are shown in Table 6-5 and include projected supply, total project cost, and unit cost.

Chapter 7 provides a detailed evaluation of the alternative strategies including how costs were derived and the process by which these strategies were selected. Figure 6-8 shows the locations of the alternative strategies. Note that these strategies are typically located further from Dallas than the recommended strategies, and consequently generally have higher construction and operation cost.

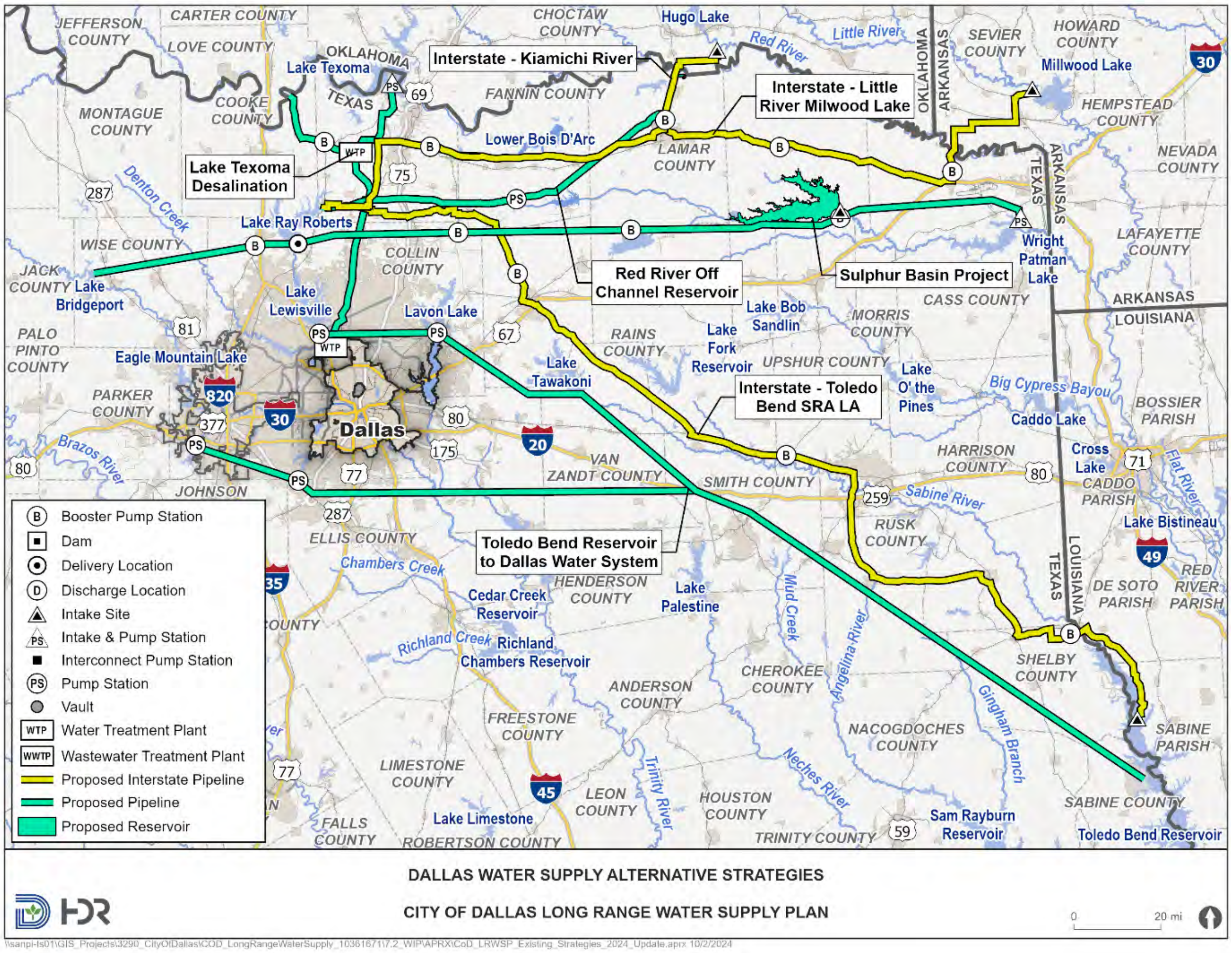
Other strategies that were considered but not designated as recommended or alternative strategies include direct reuse, aquifer storage and recovery (ASR), stormwater supplies, and riverbank filtration. After the evaluation period, the decision was made to not include these strategies as recommended or alternative designations. Further discussion on these strategies and reasons the strategies were not included as recommended or alternative will be discussed in Chapter 7.

Table 6-5. Alternative Strategies for DWU

Alternative Strategy	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Sulphur Basin Project [a]	-	-	-
High Yield	71.2	$1,552	$6.25
Low Yield	62.7	$1,472	$6.64
Interstate – Little River-Millwood Lake	268	$7,361	$6.29
Toledo Bend Reservoir to Dallas West System	89	$2,450	$6.48
Interstate – Toledo Bend SRA LA	179	$7,550	$9.57
Red River OCR	82.4	$2,062	$5.75
Interstate – Kiamichi River	268	$4,258	$3.69
Lake Texoma Desalination	130	$3,824	$9.06

[a] High yield and low yield scenarios are based on the 2024 Marvin Nichols Reservoir and Lake Wright Patman Reallocation Yield Update and are further discussed in Section 7.

Figure 6-8 Alternative Strategies for DWU



6.2.4 Approval of Dallas City Council and Coordination with Region C

Approval of Dallas City Council is pending at this time and dependent on the presentation of the recommended and alternative strategies at the November 13th, 2024, Dallas City Council meeting. The final version of this report will be updated with the council resolution approving the strategies for use in the 2024 LRWSP.

Dallas and the Region C RWPG consultants have had an open communication through the planning and development of the 2024 LRWSP which coincided with the development of the 2026 Region C RWP. Pending approval of Dallas' recommended and alternative strategies, and authorization from City Council, Dallas will provide the data from the evaluation of the recommended and alternative strategies to the Region C RWPG to be included in the 2026 Region C RWP. The inclusion of Dallas strategies in the Regional and State Water plans is necessary for certain permitting and funding requirements that may be encountered during project implementation. Dallas will request that the 2024 LRWSP be referenced and included in the 2026 Region C RWP by the Region C RWPG.

6.3 Water Supply Plan Summary

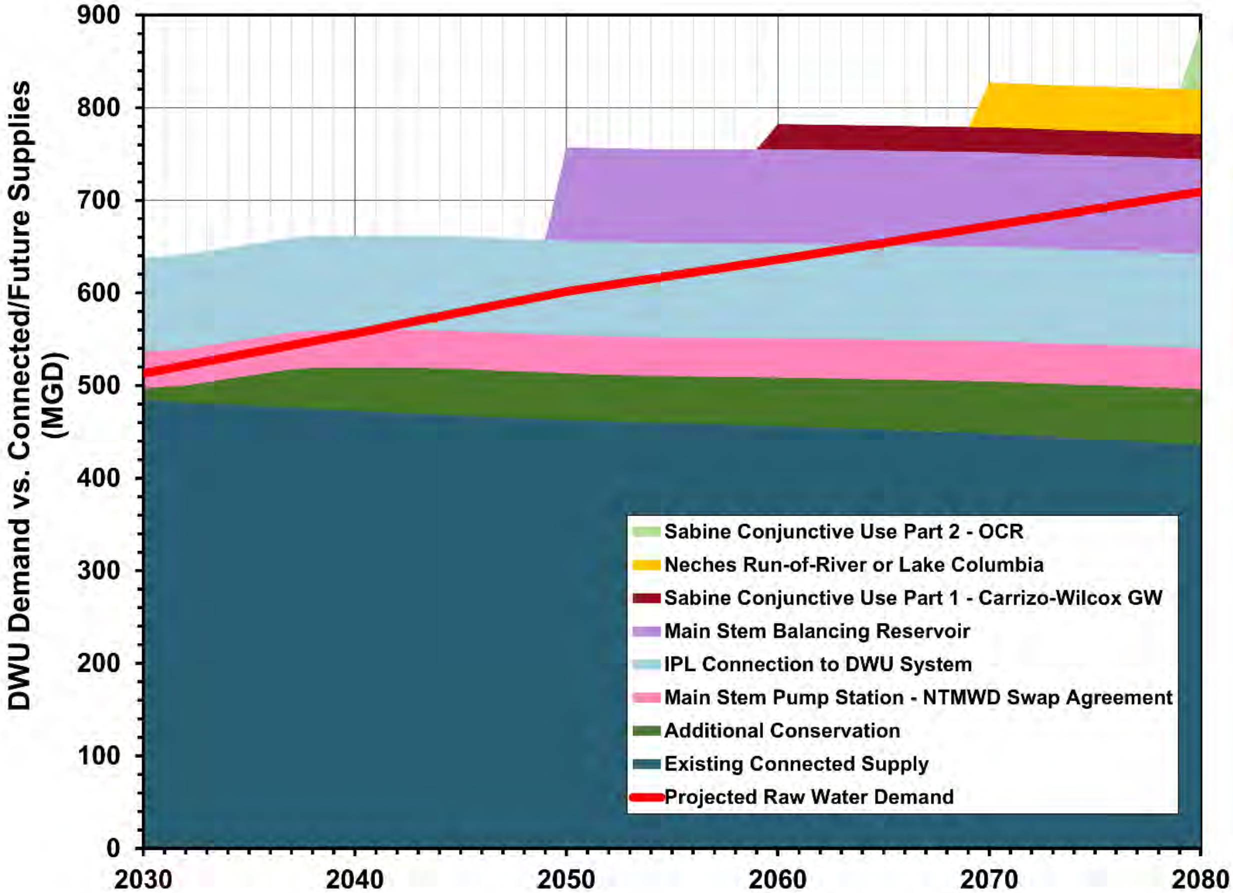
Dallas initiated the 2024 LRWSP effort in late 2022 with the goal of developing robust population and demand projections for the retail portion (City of Dallas) of the DWU service area and updating DWU Customer Cities demands using the latest Region C data. These demands were compared to the connected supplies to determine needs for DWU through the 2080 planning horizon. Recommended and alternative strategies from the 2014 LRWSP were updated for cost, availability, and equity considerations before being ranked and scored to select the strategies best suited to meet Dallas' future demands. As a result of the planning process Dallas has identified seven (7) recommended water management strategies to meet the future needs of Dallas and its customers. These recommended strategies rely heavily on conservation and reuse supplemented by the development of new supplies. These strategies have development challenges and overall risks that will need to be mitigated through the additional evaluation, feasibility, permitting, design, and implementation. The implementation timeline for the 2024 LRWSP recommended strategies is shown in Table 6-6 and Figure 6-9. Table 6-6 shows the percentage available supply buffer after connection of new supplies each decade. The 2024 LRWSP provides implementation steps for Dallas to follow to achieve the desired goal of implementing these projects in time to meet anticipated growth. These goals, projections, and solutions should be revisited by Dallas yearly as these implementation steps will need to be implemented and accounted for in annual budgeting cycles.

Table 6-6. Strategy Implementation Timeline

Table units: MGD

Demand / Supply / Strategy	2030	2040	2050	2060	2070	2080
Current System						
Projected Raw Water Demand	513.1	556.4	601.6	635.9	672.3	709.3
Existing Connected Supply	484.1	472.8	462.6	456.4	448.4	435.8
Buffer / (Deficit)	(29.0)	(83.6)	(139.0)	(179.5)	(223.9)	(273.5)
Recommended Water Management Strategies						
Additional Conservation	13.1	46.6	50.6	52.3	56.2	60.5
Main Stem Pump Station - NTMWD Swap Agreement	39	40.4	41.2	42.5	43.3	44.2
IPL Connection to the DWU System	102	102	102	102	102	102
Main Stem Balancing Reservoir	-	-	100.8	102	102	102
Sabine Conjunctive Use Part 1 – Carrizo-Wilcox GW	-	-	-	27	27	27
Neches Run-of-River or Lake Columbia	-	-	-	-	48	48
Sabine Conjunctive Use Part 2 – OCR	-	-	-	-	-	66
Total Future System						
Supply From Recommended Strategies	154.1	189.0	294.6	325.8	378.5	449.7
Total Supplies	638.2	661.8	757.2	782.2	826.9	885.5
Buffer / (Deficit)	125.1	105.4	155.6	146.3	154.6	176.2
Percent Buffer of Total Supplies	**19.6%**	**15.9%**	**20.6%**	**18.7%**	**18.7%**	**19.9%**

Figure 6-9. Strategy Implementation Timeline for DWU Total System (comparing Demands and Supplies)



7 Strategy Selection and Detailed Evaluation of Preferred Strategies

Dallas will require additional water supply within the next 50 years and the source of that water is planned to be from a combination of additional conservation, additional reuse and development of new surface water supplies. This chapter describes the screening methodology and scoring and ranking of criteria for the strategy evaluation

For the 2024 LRWSP, HDR used a strategy evaluation matrix to assist Dallas in the selection of recommended and alternative water management strategies (strategies) to meet Dallas' future needs. This evaluation matrix was used to score and rank strategies based on a set of quantitative and qualitative criteria which guided the selection of the recommended and alternative strategies for the 2024 LRWSP.

7.1 Strategy Evaluation Methodology

7.1.1 Strategy Selection Process

7.1.1.1 STRATEGY IDENTIFICATION

In the 2014 LRWSP, a conglomeration of over 300 possible water management strategies for Dallas was identified from previous studies including Dallas' 2005 LRWSP and numerous state water plans published between 1968 and 2016. Any duplicate strategies identified were refined and consolidated as appropriate. A basic and fatal flaw analysis was conducted to pare the list of strategies down to a list of only those strategies that appeared feasible or practicable. These strategies were put through the scoring and ranking process to determine the 2014 preferred strategies, which were further separated into recommended and alternative strategies for the 2014 LRWSP.

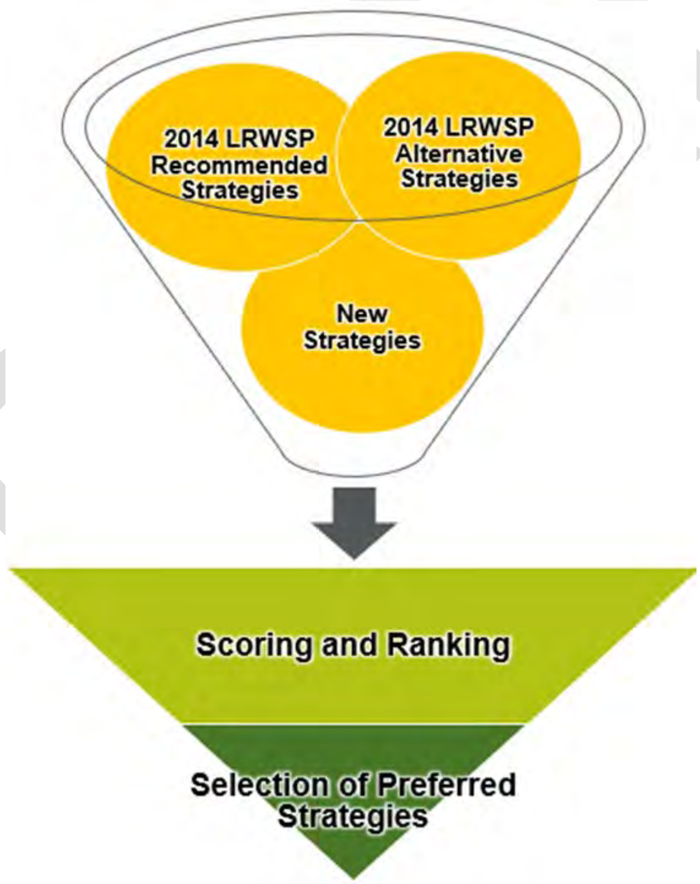
For the 2024 LRWSP, the 2014 LRWSP recommended and alternative strategies were reevaluated alongside several new strategies under the following categories: aquifer storage and recovery (ASR), interstate water supplies, stormwater supplies, and riverbank filtration. See Table 7-1 for a complete list of the new strategies. These strategies were put through the ranking and scoring process to determine the 2024 LRWSP preferred strategies Figure 7-1.

Table 7-1. Strategies Evaluated in the 2024 LRWSP

Table units: September 2023 Dollars

2014 LRWSP Recommended Strategies	2014 LRWSP Alternative Strategies	New Strategies
Additional Conservation (Dallas)	Direct Reuse – Alternative 1	Aquifer Storage and Recovery - Resiliency
Main Stem Pump Station – NTMWD Swap Agreement	Sabine Conjunctive Use • Carrizo Wilcox Groundwater (Part 1) • OCR (Part 2)	Interstate Water Supplies • Kiamichi River • Little River – Millwood Lake • Toledo Bend SRA LA
Main Stem Balancing Reservoir	Red River OCR	Stormwater Supplies
IPL Connection to the DWU System	Sabine Conjunctive Use: • Part 1 - Carrizo Wilcox Groundwater • Part 2 – Sabine River Off-Channel Reservoir	Riverbank Filtration Alternatives
Neches Run-of-River	Toledo Bend Reservoir to Dallas West System	
Lake Columbia	Lake Texoma Desalination	

Figure 7-1. Overview of the Strategy Evaluation Process



7.1.1.2 SCREENING CRITERIA

To evaluate and rank the strategies, two types of screening criteria were developed and used to provide a quantitative approach of ranking the potential strategies. The screening criteria include four quantitative criteria and five qualitative criteria.

The quantitative criteria include total project cost, unit cost, annual operational and maintenance costs, and annual water supply volume. All cost estimates were updated to September 2023 dollars for consistency with the 2026 Region C RWP. (See section 7.1.1.2.1 for further information about the costing methodologies and assumptions used in the 2024 LRWSP). Table 7-2 summarizes the quantitative screening criteria and provides a description of each of the four criteria. For each strategy, a scoring value from 1 to 5 was calculated for each criterion with a score of 5 being the most favorable score and 1 being the least favorable.

Scoring values for each criterion were assigned based on the quintile in which the strategy ranked as compared to all other potential strategies. For example, if a strategy's total project cost is in the lowest 20th percentile when ranked against all of the other potential strategies, then that strategy received a score of 5 for the total project cost criteria.

Table 7-2. Summary of Quantitative Screening Criteria

Criteria	Description	Scoring Value				
		1	2	3	4	5
Total Project Cost	The total project costs for all project components.	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Unit Cost	The cost per acre-foot of supply determined by dividing the total annual cost by the annual supply volume.					
Annual Operation & Maintenance	The annually recurring operation, maintenance and power costs (excludes debt service).					
Supply	The total annual supply available to Dallas from the project					

Five qualitative screening criteria were developed and used to allow for the inclusion of criteria focusing on potential project impacts and implementation challenges. These criteria included water quality, environmental impacts, confidence and permitting, flexibility and phasing, and equity. Table 7-3 summarizes the qualitative screening criteria and provides descriptions for each scoring value. Values range from 1 to 5 with 5 being the most favorable score and 1 being the least favorable score. Qualitative guidelines are also provided in Table 7-3 and are used to ensure consistency in the scoring process. Unlike the basic criteria, the qualitative screening criteria allowed each strategy to be scored independently from the other strategies, resulting in the relative score not being influenced by the other strategies. Since equity is a new screening criterion for the 2024 LRWSP, additional background is provided in 7.1.1.2.2 Equity Evaluation Methodology.

Table 7-3. Summary of Qualitative Screening Criteria

ENVIRONMENTAL IMPACTS		
Scoring Value	**Description**	**Guideline (Acres Impacted)**
1	High Impacts (Example: Large on-channel reservoir projects)	• Greater than 10,000
2	Medium-High Impacts (Example: Smaller on-channel reservoirs with wetlands or other issues)	• 10,000 to 5,000
3	Medium Impacts (Example: Smaller on-channel or off-channel reservoir with little or no wetlands or other issues)	• Less than 5,000
4	Low Impacts (Example: Pipeline project to an existing reservoir or a reuse project)	• Primarily Limited to • Pipeline ROW
5	No Impacts (Example: Additional conservation, operational changes)	• None

WATER QUALITY CONCERNS		
Scoring Value	**Description**	**Guideline (Water Quality Constituent)**
1	High Impacts (Example: Requires the use of reverse osmosis)	• High Total Dissolved Solids (TDS) • (Greater than 2,000 mg/L) • PFAS/PFOA constituents identified in water supply
2	Medium-High Impacts (Example: Advanced treatment or blending with another source)	• Medium TDS • (800 to 2,000 mg/L)
3	Medium Impacts (Example: Smaller level of additional treatment or increased costs)	• Impaired quality mitigated by wetland treatment or minor WTP modifications
4	Low Impacts (Example: Utilization of an existing source already being treated or one of like water quality)	• Water quality similar to an existing source
5	No Impacts (Example: No concerns, e.g., conservation)	• No increase in costs from water quality issues

CONFIDENCE/PERMITTING CHALLENGES/LEGAL ISSUES		
Scoring Value	**Description**	**Guideline (Example Projects/Permits)**
1	Substantial challenges expected. Project requires a full EIS effort or a non-exempt interbasin transfer. Potential for legal concerns from moving water across state lines or other environmental issues, bottom land hardwoods, Endangered Species Act (ESA), etc.	• Large On-Channel Reservoir; • Over allocation of Co. MAG • New / Large IBT • Major EIS
2	Lengthy and costly permitting challenges expected. Similar to 1, but without significant legal concerns, ESA or bottomland hardwood issues. Project could include expectation of a water rights contested case hearing, but simpler than a 1. Project could require groundwater permits within the MAG.	• Small On-Channel Reservoir • Large Off-Channel Reservoir • Small / Existing IBT • EIS / EA
3	Typical level of permitting expected. Project could require a water right and 404 permits, but without the expectation of a contested case hearing or NEPA analysis. Project could require groundwater permits within the MAG.	• Small Off-Channel Reservoir • Non-IBT Water Right Nationwide 404
4	Simple permitting effort expected. Project could include water right, bed and banks permit or a permitting action involving authorizations already contained in existing permits. No anticipated legal challenges.	• No Federal Permits • Bed and Banks Permits • Amendments to Existing Permits
5	Little or no permitting required or opposition expected.	• Simple Permit Amendments or No Permits Required

FLEXIBILITY AND PHASING		
Scoring Value	**Description**	**Guideline (Project Configurations)**
1	Questionable source reliability or limited options and delivery. e.g. a run of the river option in an area with a severe drought that cannot be configured or combined with other options and would only deliver to a single point in the Dallas System.	• Single configuration or • single delivery point. • Reliability concerns during historical droughts.
2	Somewhat better source reliability than a 1 but would still have issues with limited configuration options and delivery locations.	• Two configurations or • two delivery points. • Reliability concerns during future droughts.
3	A project that has sufficient reliability (surface water backed up by storage as an example) that can be delivered to different points of the Dallas system or at least to demand nodes where the supply is needed, i.e. west side system. Project could be combined with a partner.	• Multiple configurations or • multiple delivery points. • Minimal reliability concerns.
4	A project with good reliability that can be delivered to multiple points in the system or can be configured in multiple ways to meet different operational requirements.	• Multiple configurations and • multiple delivery points. • Minimal reliability concerns.
5	A project that is highly customizable with a reliable source that can be configured for delivery locations within the Dallas system. Some reuse projects are examples of this level of rank.	• Multiple configurations and • multiple delivery points. • Minimal reliability concerns. Favored source (Reuse).

EQUITY			
Scoring Value	**Description**	**Guideline (Severity, Impact Area and Time)**	
1	**Project will have highly negative impacts on socially vulnerable communities and may significantly increase inequity.** Extreme mitigation efforts would be needed to reduce the burden on socially vulnerable communities.	Significant negative impacts to socially vulnerable communities will be permanent or long-lasting.	• 50.01-100% of project is in the 4th quartile (highly vulnerable)
2	**Project will have some negative impacts on socially vulnerable communities and may slightly increase inequity.** Moderate mitigation efforts would be needed to reduce the burden of the project on socially vulnerable communities.	Negative impacts to socially vulnerable communities will be temporary and short-lived.	• 25.01-50% of project is in the 4th quartile • 50.01-100% project is in 3rd quartile
3	**Project provides no enhancement for socially vulnerable communities but does not increase inequity**. Mitigation is not necessary, or low mitigation efforts would be effective in removing the majority of project burdens from socially vulnerable communities.	Neutral impacts to socially vulnerable communities.	• 0.01-25% of project is in 4th quartile • 0-50% of project is in 3rd quartile
4	**Project provides some enhancement for socially vulnerable communities.** Mitigation is not necessary, or low mitigation efforts would be effective in removing the majority of project burdens from underserved communities.	Positive impacts to socially vulnerable communities will be temporary and short-lived.	• 0% of project is in 4th quartile • 0-25% of project is in 3rd quartile • 75-99.9% of project is in the 1st or 2nd quartile
5	**Project provides significant enhancement for socially vulnerable communities.** Mitigation is not necessary, or low mitigation efforts would be effective in removing the majority of project burdens from underserved communities.	Significant positive impacts to socially vulnerable communities will be permanent or long-lasting.	• 0% of project is in the 3rd or 4th quartile • 100% of project is in the 1st or 2nd quartile

7.1.1.2.1 COSTING METHODOLOGIES AND ASSUMPTIONS

The 2024 Dallas LRWSP relied on the TWDB Unified Costing Model (UCM) version 3.0.1 to develop planning level cost estimates for new and updated strategies to compare strategies on a similar basis for cost. However, if a strategy already has a more detailed or recent estimate or is the result of another ongoing study, those estimates were used in the 2024 Dallas LRWSP and formatted to be comparable with the other estimates using the UCM. For the development of the 2026 Regional Water Plans, the TWDB stipulated that all strategies will use September 2023 dollars, and this assumption was used in the LRWSP except if noted in the strategy write ups. The 2024 LRWSP used the TWDB General Guidelines and assumptions about pumps and crossing lengths (see Table 7-4) unless otherwise noted to keep a consistent comparison between strategies and the 2026 Region C Regional Water Plan.

Table 7-4. TWDB 2026 Regional Water Planning Costing: General Guidelines and Suggested Assumptions

	Interest During Construction	3.50%	
TWDB General Guidelines	Rate of Return on Investments	0.50%	
	Construction Period	1.0	years
	Engineering - Planning	3%	
	Engineering - Design	7%	
	Construction Engineering	1%	
	Legal Assistance	2%	
	Fiscal Services	2%	
	Contingency for Pipelines	15%	
	Contingency for All Other Facilities	20%	
	Debt Service (Non-Reservoirs) Period	20	years
	Debt Service (Reservoirs) Period	40	years
	Annual Interest Rate (Non-Reservoirs)	3.50%	
	Annual Interest Rate (Reservoirs)	3.50%	
	Operations & Maintenance (Pipelines)	1.00%	% of Capital Costs
	Operations & Maintenance (Pump Stations)	2.50%	% of Capital Costs
	Operations & Maintenance (Dams)	1.50%	% of Capital Costs
	Power Costs	$0.09	/kilowatt-hour
Pumps & Crossings	Power Connection Costs - Pump Stations	$200	/HP
	Pump Station Tank Option	GST w/ Roof	
	Pump Station Tank(s) - % of Daily Flow for Sizing	10%	
	Recommended Crossing Length (2-Lane Roads)	115	LF
	Recommended Crossing Length (4-Lane Divided Highway)	210	LF
	Recommended Crossing Length (6-Lane Divided Highway)	240	LF
	Recommended Crossing Length (Railways)	100	LF

7.1.1.2.2 EQUITY EVALUATION METHODOLOGY

The City of Dallas is committed to considering equity as part of its LRWSP. The bullets below outline the City's definition of equity:

- "Equity means that each person has the resources and services necessary to thrive in each person's own unique identities, circumstances, and histories.
- Equity focuses on eliminating disparities while improving outcomes for all.
- Racial equity is a situation that is achieved when people are thriving and neither race nor ethnicity statistically dictates, determines, or predicts one's social outcome or ability to thrive."[1]

Building water supply projects can place stress on communities due to construction disruptions to traffic and water supply as well as the displacement of people for project

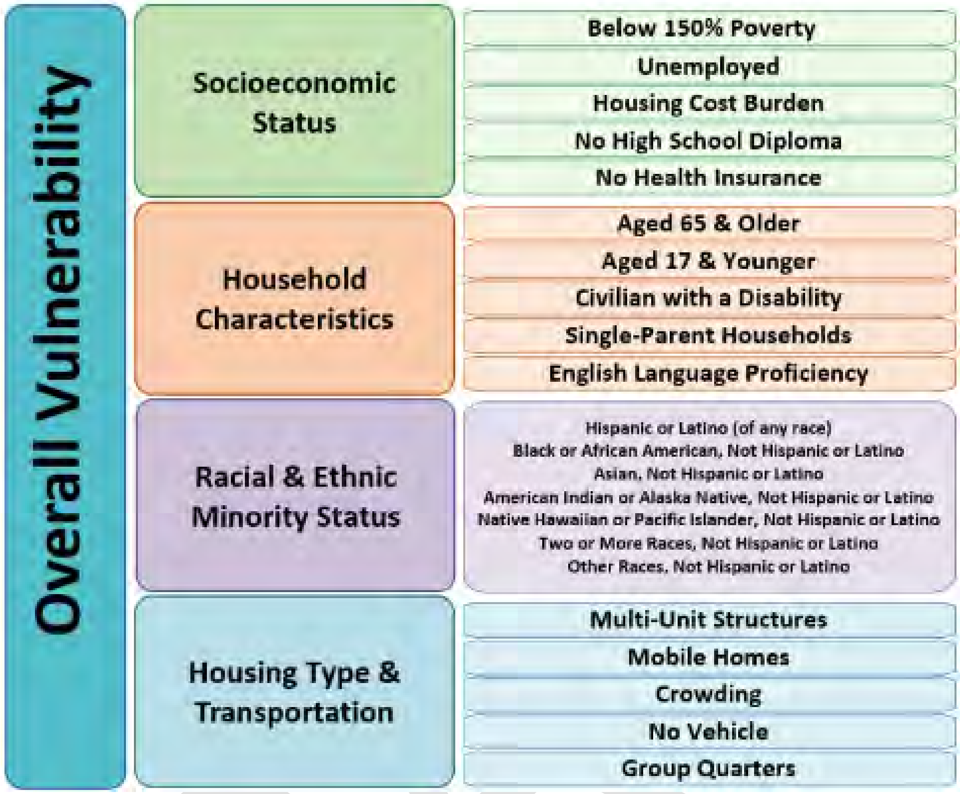
[1] City of Dallas' Equity Division's Website Homepage: Equity Division Home (dallascityhall.com), accessed May 13th, 2024.

infrastructure, or potential property damage from unforeseen project issues. The severity to which different communities experience these stressors are often felt disproportionately by communities that are least able to plan for, cope with, and recover from adverse impacts from these stressors. Some communities are more vulnerable than others to natural or human made hazards. “Social Vulnerability refers to the demographic and socioeconomic factors (such as poverty, lack of access to transportation, and crowded housing) that adversely affect communities that encounter hazards and other community-level stressors.”[2] There are many socioeconomic metrics and datasets that can be used to evaluate social vulnerability. Ultimately for the 2024 LRWSP, the Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry’s Social Vulnerability Index (hereafter, CDC SVI or SVI) was selected to evaluate equity for each strategy to examine if socioeconomically vulnerable groups would be disproportionately exposed to strategy disruptions or hazards.

“SVI indicates the relative vulnerability of every U.S. census tract. Census tracts are subdivisions of counties for which the Census collects statistical data. SVI ranks the tracts on 16 social factors…[grouped] into four related themes. Thus, each tract receives a ranking for each Census variable and for each of the four themes as well as an overall ranking.”[3] See Figure 7-2 for the social factors that fit into the four themes of Socioeconomic Status, Household Characteristics, Racial and Ethnic Minority Status, and Housing Type and Transportation. To streamline the evaluation process, the overall summary ranking variable that provides a composite ranking of each census tract across all four themes was used to aid in the scoring of each strategy in the 2024 LRWSP. The rankings are based on percentiles, with an overall ranking between 0.75 and 1 indicating that the area falls within the 4th quartile or top 25% and has the highest vulnerability. The first quartile, 0 to 0.25, is the lowest 25% and indicates the area has a low vulnerability to stressors or disruptions.

[2] CDC/ATSDR Social Vulnerability Index (CDC/ATSDR SVI)
[3] https://svi.cdc.gov/Documents/FactSheet/SVIFactSheet.pdf

Figure 7-2. CDC SVI Themes and Indices



Source: CDC: https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

The CDC's SVI was selected to evaluate equity for the 2024 LRWSP due to its availability of data across the entire multistate strategy areas at a consistent scale, the spread of indices across multiple themes, easy replicability, and use of the index as part of the U.S. Climate Resilience Toolkit,[4] several published papers[5], and by the City of Dallas' Office of Equity and Resilience as part of their 5 Key Questions for Equity Impact Assessment.

The City of Dallas' Office of Equity and Resilience's list of 5 Key Questions for Equity Impact Assessment provides questions used to "identify communities that are at high risk and vulnerable to prolonged hardship with less resources for recovery following COVID-19." For the 2024 LRWSP, it was assumed that these same communities would be vulnerable and have less resources for recovery following disruptions in water supply and construction obstacles. The questions are as follows:

1. "Do Black, Hispanic and Native American populations together makeup more than 70% of the community?
2. Does the area have 15% or more of its families at or below 100% of the federal poverty level?
3. Do less than 50% of the area's households own the home they live in?

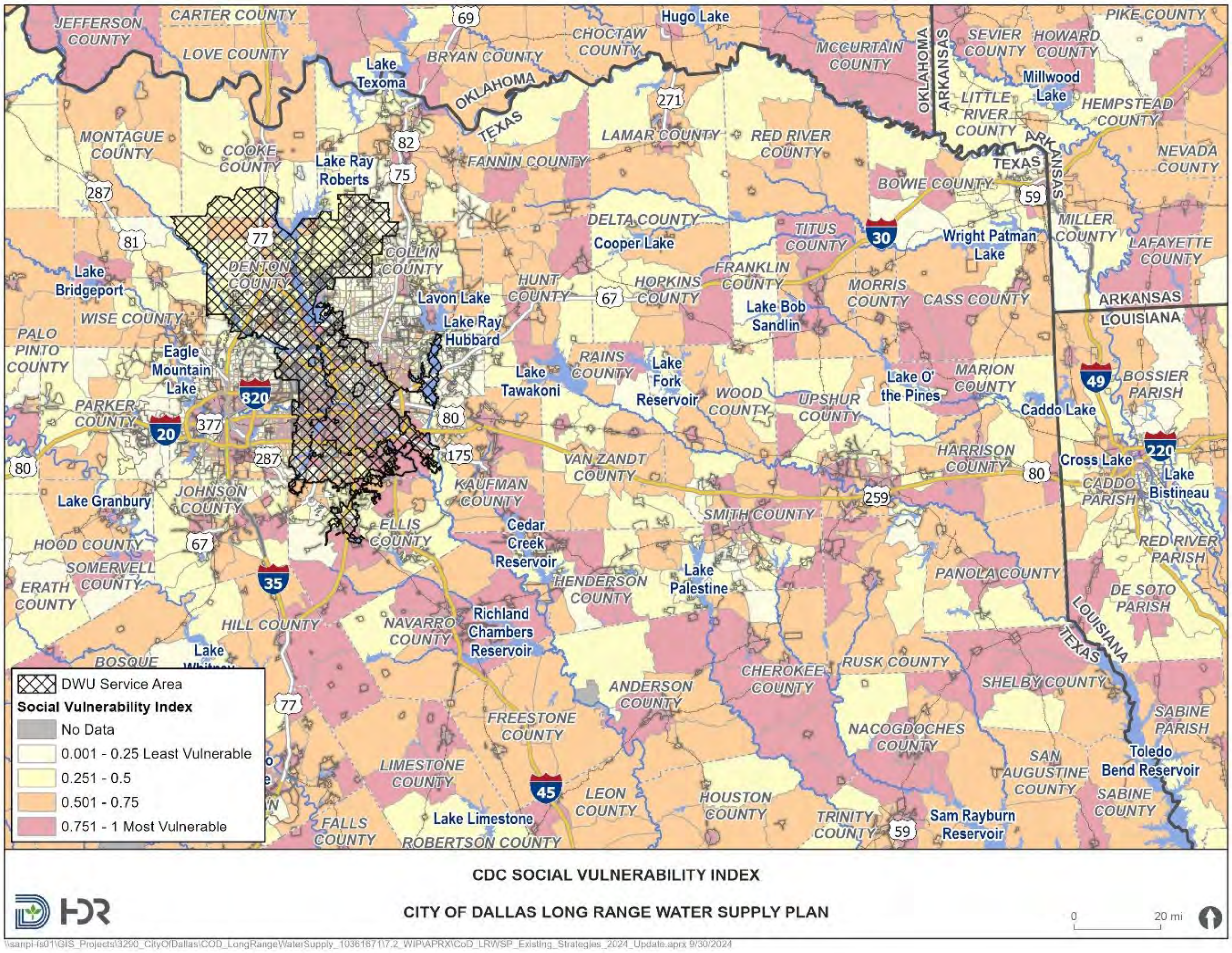
[4] Social Vulnerability Index | U.S. Climate Resilience Toolkit
[5] https://www.atsdr.cdc.gov/placeandhealth/svi/publications/publications_materials.html

4. Is the area rated “High” on the CDC’s Social Vulnerability Index, Socioeconomic Level?
5. Are more than 12% of the area’s residents 65 or older?

Upon further evaluation, questions 1,2,3, and 5 all ask about demographic information fully or partially captured in the CDC’s Social Vulnerability Index.

For the equity evaluation, the physical strategy infrastructure (i.e., wellfield locations, pipeline routes, booster stations, etc.), were overlayed over the most recent U.S. CDC SVI data from 2022 in ArcGIS Pro to spatially outline the current demographics in Dallas and potential project areas Figure 7-3. Summary statistics of the data indicators were generated for each alternative to inform the equity score for each strategy. The evaluation of the strategy infrastructure with the U.S. CDC SVI data was based on the percentage of project area located in each quartile. The quartiles are color coded on the map. Suggested scoring values of 1 through 5 are associated with the percent of project impact area in each quartile and were defined in Table 7-3. An equity score of 1 indicates over 50% of the project area is in the 4th quartile and highly negative impacts on socially vulnerable communities are anticipated. The scoring guidelines are intended to help identify strategies with significant infrastructure area in vulnerable quartiles and gauge the level of mitigation that may be needed. Consideration regarding the scoring guidelines may be given to strategies depending on the project infrastructure since, for example, the development of new reservoirs may have different impacts than the placement of a pipeline. Consideration is strategy dependent and was discussed in the strategy evaluations as necessary.

Figure 7-3. CDC's Social Vulnerability Index Map



7.1.1.3 SCORING USING A STRATEGY EVALUATION MATRIX

For each screening criteria, a score was entered into the strategy evaluation matrix, which is the tool used for the screening analysis. Then scoring weights were applied to all 9 criteria to define a maximum score that could be achieved by a strategy that scores a 5 in all 9 criteria as illustrated in Table 7-5.

Table 7-5. Scoring Weights

Scoring Weights for Quantitative Criteria			
Total Project cost	Unit Cost	Supply	Operations and Maintenance
7	2	7.25	8.75
Quantitative Potential Total Score: 125			

Scoring Weights for Qualitative Criteria				
Environmental Impacts	Confidence and Permitting	Flexibility and Phasing	Water Quality	Equity Impacts
8	5	4	4	4
Qualitative Potential Total Score: 125				
Combined Potential Total Sore: 250				

7.1.1.4 SCREENING RESULTS

Figure 7-4 through Figure 7-6 present the screening results. The strategies are color coded according to the type of strategy, e.g. existing reservoir, conservation, reuse, etc. Quantitative criteria scores are represented by solid bars and qualitative criteria scores are represented by hashed bars. It is important to note the Main Stem Pump Station – NTMWD Swap Agreement, ASR, Riverbank filtration, and Stormwater strategies are not included in these graphs. The Swap agreement project is constructed pending finalization of the swap agreement and is all but finalized., ASR is considered a resiliency strategy and does not provide new supply, therefore is not scored along with the other potential supply strategies., Riverbank filtration is a potential variation to 3 specific strategies with large reiver intakes and not a standalone strategy. Stormwater strategies were investigated but no DWU specific strategy was identified for comparison against the other supply strategies. Another consideration is that for the Neches projects, either the Neches Run-of-River project or the Lake Columbia projects could be implemented but not both, since these rely on the same available pipeline capacity in the IPL.

Figure 7-4 presents the quantitative scores for all of the potential strategies. For the quantitative criteria, the reuse strategies typically had higher scores because of the close proximity to Dallas, which reduces transmission, infrastructure and land acquisition costs. Groundwater strategies also tend to have lower infrastructure and land acquisition costs, resulting in higher quantitative criteria scores. The reservoir strategies typically have greater transmission distances, land acquisition costs, and infrastructure costs compared to the reuse and groundwater strategies. The OCR and run-of-the-river diversion strategies typically fell in the middle of the rankings as costs typically were less than the reservoir strategies but more than the reuse and groundwater strategies. Since three of the four quantitative criteria focus on costs components, the lower supply volume from the reuse and groundwater strategies does not prevent these strategies from scoring well in the quantitative criteria rankings.

Figure 7-4. Quantitative Scores of Potential strategies

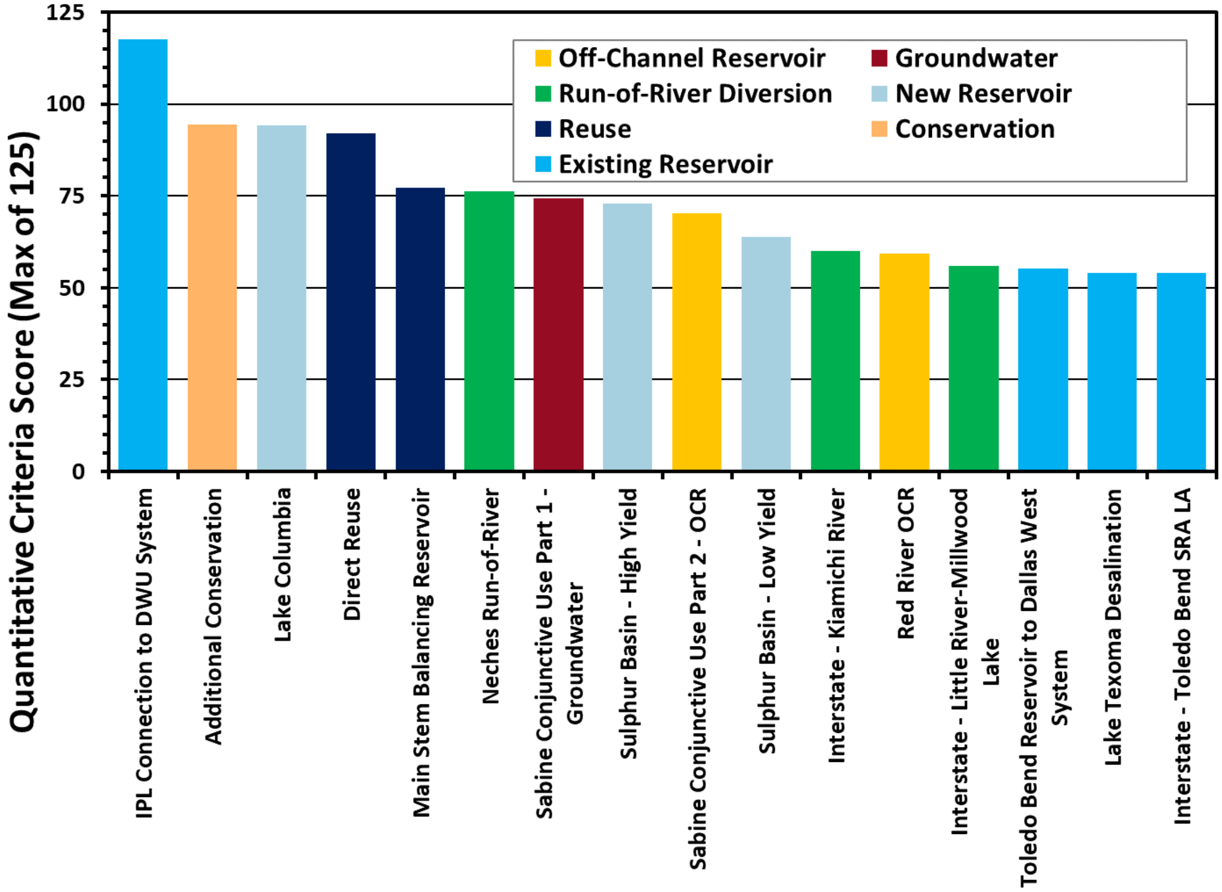


Figure 7-4 presents the scoring results for the qualitative criteria. The reuse and conservation strategies received higher rankings because of the low environmental impacts and lower permitting challenges and legal issues. The new and existing reservoirs received lower rankings because they tend to have greater environmental impacts and more permitting and legal issues compared to the reuse and conservation strategies. However, the Main Stem Balancing Reservoir strategy is an exception. Main Stem Balancing Reservoir ranked highly in the qualitative criteria scoring since the strategy has a reuse component with lower permitting challenges and a high potential for flexibility and phasing.

Figure 7-5. Qualitative Scores of Potential strategies

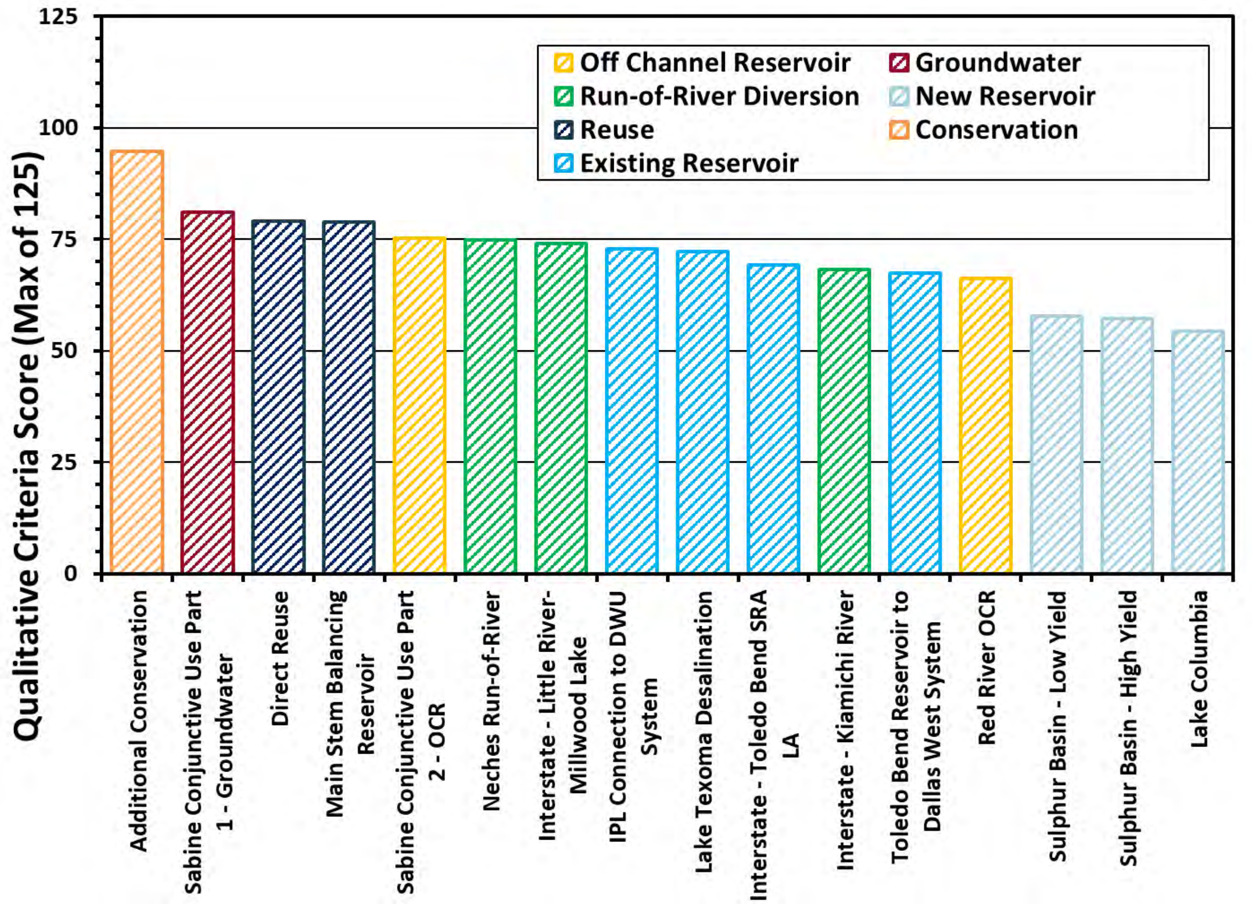
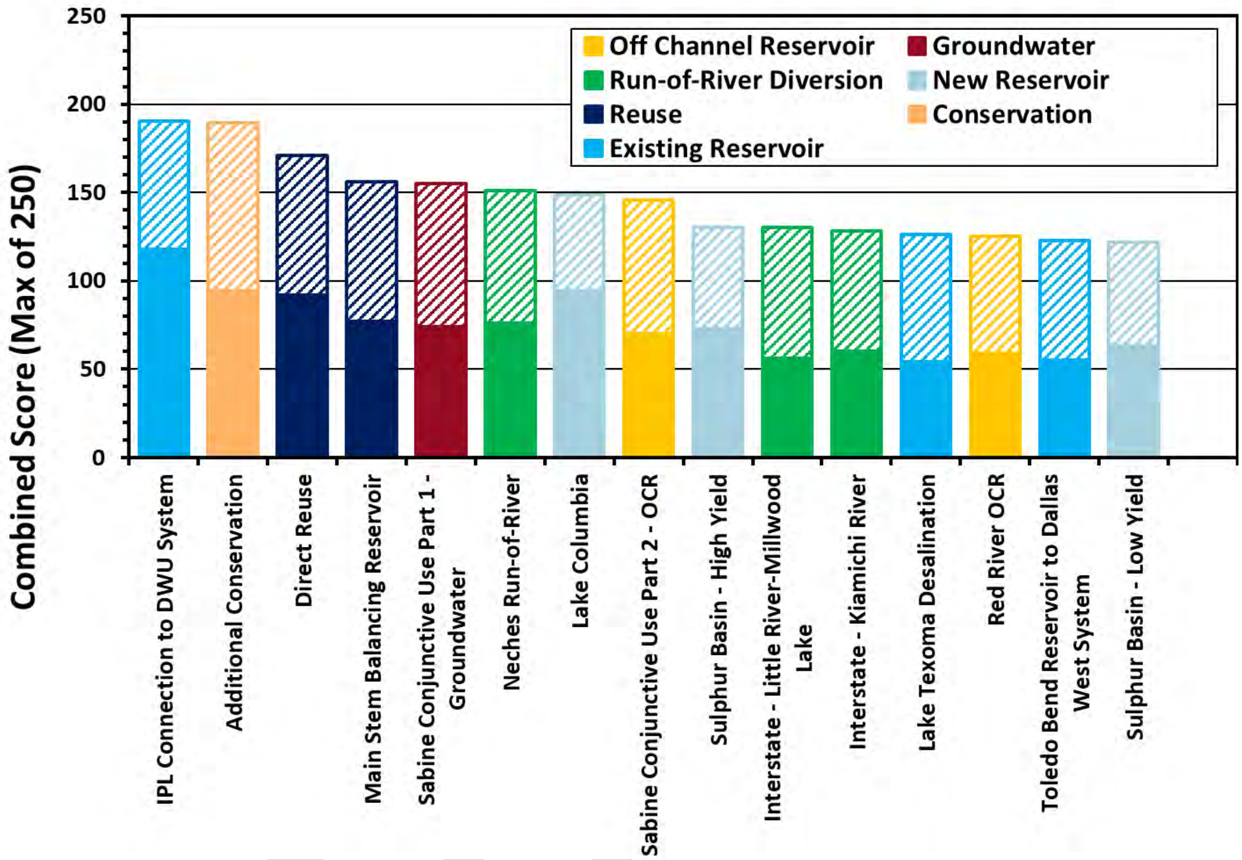


Figure 7-6 presents the combined strategy scoring results. The ranking shows that the IPL Connection to the DWU System and additional conservation are the two highest ranked strategies. These strategies are followed by reuse strategies, and the Sabine Conjunctive Use Part 1 - Carrizo Wilcox Groundwater strategy. The lower end of the ranking is comprised mostly of new and existing reservoir strategies and the interstate strategies.

Figure 7-6. Combined (Quantitative and Qualitative Scores) of Potential strategies



7.1.2 Preferred Strategies

The total combined score for each of the potential strategies was an important consideration in selecting the preferred strategies for Dallas. The selection of the preferred strategies is a result of recognizing how the ranked potential strategies can be formulated into a plan to meet Dallas needs. Preferred strategies were subsequently divided into recommended and alternative strategies considering how each strategy could be incorporated into the Dallas system to meet future water supply needs as discussed in Chapter 6. Characteristics such as flexibility, supply volume, and reliability were considered as part of this selection. Recommended strategies are strategies that Dallas will actively pursue and implement in the future to meet the needs identified in the 2024 LRWSP. The alternative strategies will serve as potential back-up strategies that could replace a recommended strategy if it were to be removed from consideration at a future date due to implementation issues.

7.1.3 Recommended and Alternative Strategies

Table 7-6 presents the strategies selected as recommended and alternatives for the 2024 LRWSP. Table 7-7 provides a summary of the recommended and alternative strategies and the associated characteristics which were evaluated as part of the 2024

Dallas LRWSP. Combined summary maps of the recommended and alternative strategies were presented in Chapter 6. Individual strategy maps and further details on each strategy's characteristics are presented in sections 7.2 through 7.18.

Table 7-6. Recommended and Alternative Strategies for DWU

Recommended Strategies
Additional Conservation
Main Stem Pump Station - NTMWD Swap Agreement
IPL Connection to the DWU System
Neches River Basin Supply
Neches Run-of-River
Lake Columbia
Sabine Conjunctive Use: Part 1 - Carrizo Wilcox Groundwater Part 2 – Sabine River Off-Channel Reservoir
Main Stem Balancing Reservoir
Alternative Strategies
Sulphur Basin Project
High Yield
Low Yield
Interstate – Little River-Millwood Lake
Toledo Bend Reservoir to Dallas West System
Interstate – Toledo Bend SRA LA
Red River OCR
Interstate – Kiamichi River
Lake Texoma Desalination

Table 7-7. Recommended and Alternative Strategy Characteristic Summary

Strategy	Selection	Supply (MGD)	Total Project ($ Millions)	Annual ($ Millions)	Unit Cost ($/acft)	Unit Cost ($/1,000 gal)	Environmental	Permitting	Flexibility & Phasing	Water Quality	Equity
Additional Conservation	Rec.	60.5	$ 391	$ 13	$ -	$ 0.43	4.8	4.3	3.7	4.6	2.0
Main Stem Pump Station - NTMWD Swap Agreement	Rec.	44.2	N/A*	N/A*	N/A*	N/A*	N/A*	N/A*	N/A*	N/A*	N/A*
Main Stem Balancing Reservoir	Rec.	102	$ 1,767	$ 138	$ 1,209	$ 3.71	3.0	3.3	4.3	2.5	3.0
IPL Connection to DWU System	Rec.	102	$ 587	$ 45	$ 395	$ 1.21	4.2	3.4	3.3	3.2	1.0
Neches Run-of-River	Rec.	48	$ 719	$ 69	$ 1,290	$ 3.96	4.0	3.5	3.4	4.5	1.0
Lake Columbia	Rec.	50	$ 685	$ 60	$ 1,076	$ 3.30	2.1	2.7	3.2	3.5	1.1
Direct Reuse	-	2.2	$ 36	$ 3	$ 1,215	$ 3.73	4.3	3.2	3.3	3.2	2.0
Sabine Conjunctive Use Part 1 - Groundwater	Rec.	27	$ 695	$ 59	$ 1,971	$ 6.05	3.3	3.4	2.8	3.8	3.0
Sabine Conjunctive Use Part 2 - OCR	Rec.	66	$ 903	$ 75	$ 1,004	$ 3.08	3.3	3.2	3.9	4.1	2.0
Red River OCR	Alt.	82	$ 2,062	$ 173	$ 1,875	$ 5.75	3.9	2.1	2.8	2.3	2.0
Sulphur Basin - Low Yield	Alt.	62.8	$ 1,472	$ 152	$ 2,164	$ 6.64	1.7	2.8	2.8	3.5	2.0
Sulphur Basin - High Yield	Alt.	71.2	$ 1,552	$ 163	$ 2,038	$ 6.25	1.8	2.5	2.9	3.6	2.0
Toledo Bend Reservoir to Dallas West System	Alt.	89	$ 2,450	$ 211	$ 2,110	$ 6.48	2.8	3.0	2.8	3.7	2.0
Lake Texoma Desalination	Alt.	130	$ 3,824	$ 431	$ 2,953	$ 9.06	3.8	2.2	2.6	1.8	3.0
Interstate - Kiamichi River	Alt.	268	$ 4,258	$ 361	$ 1,203	$ 3.69	3.4	2.1	2.6	1.8	3.0
Interstate - Little River-Millwood Lake	Alt.	268	$ 7,361	$ 615	$ 2,051	$ 6.29	3.2	2.5	2.7	3.9	3.0
Interstate - Toledo Bend SRA LA	Alt.	179	$ 7,550	$ 623	$ 3,117	$ 9.57	3.6	2.5	2.4	3.7	2.0

*Note: Main Stem Pump Station - NTMWD Swap Agreement project is constructed pending finalization of the swap agreement.

7.2 Additional Conservation

Additional Water Conservation was a recommended strategy in the 2014 LRWSP and is once again a recommended water supply strategy for the 2024 LRWSP.

As stated in the City of Dallas Water Conservation Five-Year Work Plan, water conservation is defined as “those practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses” (Texas Water Code §11.002 (a) (8) (B)).

Utilities that hold water rights in excess of 1,000 acft/yr are required by the State of Texas in 30 Texas Administrative Code (TAC), Chapter 288 to submit and implement a water conservation plan and prepare updates to the plan on a specified schedule. To meet these requirements, the City of Dallas has prepared the following documents:

- The *City of Dallas Water Conservation Five-Year Work Plan* (the “Work Plan”). The Work Plan is updated approximately every five years, as required by the state. The current version was completed in 2024. The Work Plan includes a list of Best Management Practices (BMPs) and policy recommendations that are developed through detailed analysis and stakeholder input. The Work Plan contains detailed analyses of an extensive list of potential water conservation strategies for which water savings, avoided water and wastewater O&M costs, and additional revenue from enhanced apparent loss reduction is provided.
- The *City of Dallas Water Conservation Plan* (or the “Water Conservation Plan”). The Water Conservation Plan is prepared to meet the regulatory requirement specified in 30 TAC 288. The Water Conservation Plan is based on the information contained in the Work Plan and presents an analysis of water conservation strategies adopted for implementation by DWU. Both plans provide a substantial amount of information regarding the near-term (5 years) water conservation efforts adopted for the City of Dallas. The latest version of the Water Conservation Plan was approved by the Dallas City Council on April 10, 2024

An in-depth evaluation of different conservation measures was performed as part of the water demand analysis. For the 2024 LRWSP, conservation is evaluated as a supply, not a demand reduction, therefore, additional water conservation is being evaluated as a water supply strategy.

7.2.1 Strategy Description

The retail service area demand projections for DWU were developed using the Demand Side Management Least Cost Planning Decision Support System Model (DSS Model) to develop water demand forecasts through the year 2080. The DSS Model is an “end use” model that breaks down total water production to specific water end uses. The “bottom-up” approach allows for detailed criteria to be considered when estimating future demands while measuring the effects of fixture replacement, plumbing codes, and conservation efforts. The DSS Model was utilized to incorporate the benefits of 17 conservation measures selected by DWU staff.

The conservation measures are an enhanced/modified conservation program with more aggressive conservation that include current measures (existing conservation measures implemented by DWU), measures identified in the 5-year DWU Conservation Work Plan, and additional measures selected with stakeholder input. Additional conservation measures offer significant water savings and include a suite of water use efficiency measures that will help the utility to meet its short- and long- term water efficiency goals. The conservation measures are shown in Table 7-8.

Table 7-8. Conservation Measures

Conservation Measures	
Current Measures	
Residential and Industrial, Commercial, Institutional (ICI) Water Efficiency Surveys	Landscape Irrigation Ordinance
City Facility Retrofits	Minor Pluming Repair (MPR)
Conservation Tiered Rates	Public Outreach & Education (including ICI Water Efficiency Program Training)
Enhanced Irrigation Enforcement Initiative	Residential Toilet Vouchers & Rebates (NTFYH)
ICI Incentive	School Education
Irrigation Systems Evaluations	Water Loss
Future Measures	
Advanced Metering Infrastructure (AMI)	Residential Irrigation System Incentives
Fixture Retrofit on Resale Ordinance	Water Conservation Policy in New/Existing Supply Contracts
ICI Nonprofit Plumbing Retrofits	-

7.2.1.1 CONSERVATION MEASURES

The existing and enhanced, proposed conservation measures are described in Table 7-9.

Table 7-9 Conservation Measure Descriptions

Measure Name	Description
Water Loss	DWU maintains a thorough annual accounting of water production, sales by customer class and quantity of water produced but not sold (non-revenue water) and has a comprehensive program to meter water diverted from supply sources within the DWU water system. All production meters are tested and calibrated in accordance with DWU standards. DWU operates a Leak Detection Program as part of their overall water conservation effort which provides complete surveying of the water distribution system.
Conservation Tiered Rates	DWU has an inverted block conservation rate structure that requires customers to pay a higher rate for higher volumes of water used. The threshold for the higher rate is 30,000 gallons/month for residential customers and 10,000 gallons/month and more than 1.4 times their annual monthly average for commercial customers.
Public Outreach & Education	DWU maintains a public awareness campaign promoting water conservation using in-house creatives distributed across a variety of outlets. DWU also hosts seminars, workshops, and events and contributes to a regional public awareness campaign with two other water providers to produce collaborative messaging that expands across the region. This measure also includes a water efficiency training program for ICI facility managers and irrigators.
School Education	DWU provides education programs for grades K-12. Known as the Environmental Education Initiative (EII), this program also offers professional development and a dedicated website with online resources for teachers. DWU also sponsors a water conservation art contest for students in grades 1-12.
Advanced Metering Infrastructure (AMI)	Retrofit system with AMI meters and associated network capable of providing continuous consumption data to Utility offices. Includes a billing reporting tool such as WaterSmart or another customer-facing portal giving customers access to their usage. A ten-year meter replacement would be a reasonable objective. Target larger irrigation customers and customers exhibiting high water use first during rollout.
Irrigation Systems Evaluations	DWU provides free irrigation system evaluations for residential and commercial customers, usually in response to high bill concerns. Texas Commission on Environmental Quality (TCEQ)-licensed irrigators evaluate the irrigation systems for potential water loss, diagnose equipment malfunctions, and recommend irrigation controller schedule updates and/or equipment updates to enhance efficiency.
Residential Irrigation System Incentives	Provide a rebate for residential properties to retrofit their irrigation systems with water-conserving equipment such as soil moisture sensors, weather-based irrigation controllers, rotating sprinklers, and drip irrigation. This measure is intended to complement the landscape ordinance and water budget initiatives.
ICI Incentives	Provide a rebate, not to exceed $100,000 of either half of the project cost or at the rate of $0.96/1,000 gallons saved over the project lifetime (maximum 10 years). This includes both indoor and outdoor projects, but primarily indoor. An outdoor irrigation component may be added in five years but is not part of this measure's current design. To be eligible, customers must participate in an ICI Water Efficiency Opportunity Survey (among other requirements).
Enhanced Irrigation Enforcement Initiative	DWU maintains a permanent program with Dallas Code Compliance (DCC) for systematic and continued enhanced enforcement from April 1- October 31 of each year. The program includes vehicle signage, inserts and handouts, and additional overtime funding to provide periodic enforcement coverage from 4 a.m. to 8 a.m. and from 8 p.m. to midnight. This is effectively the enforcement piece of the City of Dallas's Water Waste Ordinance which sets watering restrictions during times of drought and prohibits water waste.

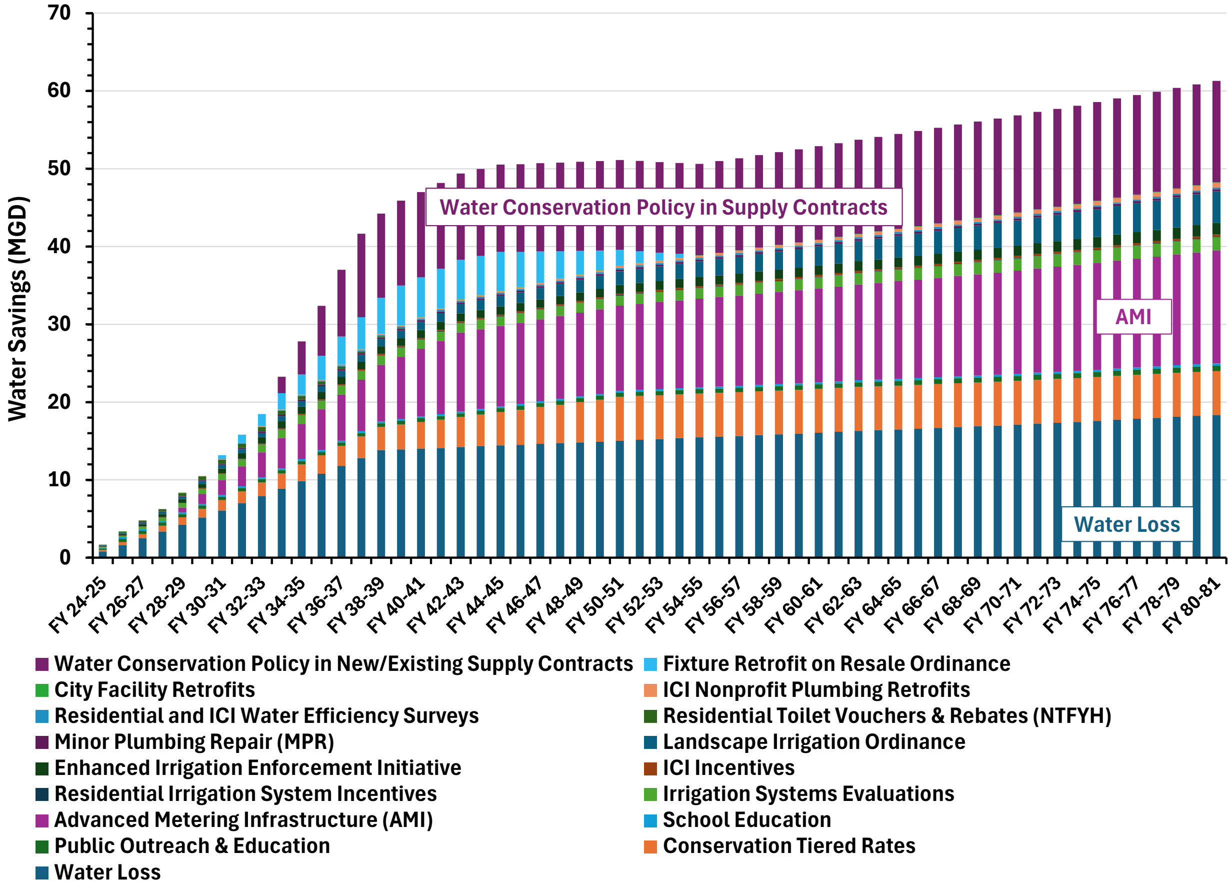
Measure Name	Description
Landscape Irrigation Ordinance	DWU maintains a landscape ordinance requiring irrigation permits for new installations and additions of sprinkler heads and/or zone valves to existing irrigation systems, as well as requires installers of an irrigation system to be licensed as required by the commission (TCEQ). There are also irrigation plan requirements related to backflow prevention, sprinkler head placement, and programmable irrigation controllers with rain sensing. Might expand to include landscape water budgets required for customers.
Minor Plumbing Repair	Repair or replace inefficient water use fixtures with water efficient fixtures, including toilets (up to two per household), faucets and faucet aerators, showerheads, hose bibs, and easily accessible pipe joint leaks. Future additions could include installing pressure regulating valves on existing properties with pressure exceeding 80 psi.
Residential Toilet Vouchers & Rebates	Offer free vouchers and rebates of up to $90 dollars per toilet on qualifying older toilets for up to two toilets per household. The multifamily (MF) program assists multifamily customers in replacing older fixtures, such as showerheads and toilets.
Residential and ICI Water Efficiency Surveys	Provide free assessments to ICI & MF customers to identify opportunities for customers to increase water use efficiency and reduce water/wastewater/energy costs in and around their properties. These evaluations include recommendations for process and equipment upgrades. This measure also includes an added single family residential indoor survey component, targeting single family residents with high was use and providing a customized report to owner.
ICI Nonprofit Plumbing Retrofits	Provide authorized domestic plumbing retrofits for qualifying nonprofit facilities (customers in good standing, with properties built prior to 1994, able to provide proof of nonprofit status, among other requirements). This program would be administered in house and conducted by a licensed plumbing contractor selected through an RFP process. Authorized retrofits under this program would include replacement of high-flow toilets and high-flow faucet aerators.
City Facility Retrofits	Fund retrofits at City facilities, including replacement of indoor plumbing fixtures and outdoor irrigation audits and corresponding irrigation system/landscaping improvements.
Fixture Retrofit on Resale Ordinance	Work with the real estate industry to require a certificate of compliance be submitted to the Utility that verifies that a plumber has inspected the property, and efficient fixtures were either already there or installed before close of escrow. If a fixture/fitting does not meet standards, it must be replaced with a fixture that meets current City standards. Alternatively, this measure could offer a complimentary site audit when requested. Site visits could include free aerators, free showerheads, and fixture rebates when applicable.
Water Conservation Policy in New/Existing Supply Contracts	Work with policy makers to require conservation and potential savings targets in contracts for additional water supply from the Utility for the outside areas served. Also, seasonal rates can fund conservation programs. DWU would provide free devices, public information, and coordinate regional incentive efforts.

7.2.2 Water Availability

Implementing the conservation measures using the timeline in Figure 7-8 is projected to have an initial cumulative water savings of 35 MGD of water over the next 5 years (FY 24-30).

Additionally, through complete implementation of the conservation measures, DWU is projected to have a water savings, or available supply, of 60.5 MGD in 2080. The increase in water savings over the next five decades due to implementation of the selected conservation measures is shown in Figure 7-7.

Figure 7-7. Yearly Conservation Savings



The conservation measures contributing significantly to savings and additional supply are water loss, advanced metering infrastructure (AMI), and water conservation policy in new/existing wholesale water supply contracts. Further information on the water savings volume provided by each measure each year can be found in the DSS Water Demand & Conservation Model provided to DWU.

A summary of the projected water savings illustrated in Figure 7-7 for each decadal year is provided in Table 7-10.

Table 7-10. Projected Available Supply Due to Conservation

Year	Water Savings (MGD)
FY 30-31	13.1
FY 40-41	46.6
FY 50-51	50.6
FY 60-61	52.3
FY 70-71	56.2
FY 80-81	60.5

7.2.3 Project Cost Estimate

There are yearly project costs to implement the conservation measures for both DWU and their retail customers. Customer costs are associated with the cost of implementing measures that are paid by the retail customers, meaning the remainder of a measure's cost that is not covered by DWU as a rebate or incentive.

The costs developed for each measure are based on industry knowledge, past experience, and data provided by DWU. Costs may include incentive costs, usually determined on a per-participant basis; fixed costs such as marketing; variable costs, such as the cost to staff the measures and to obtain and maintain equipment; and a one-time set-up cost. Measure costs are estimated each year through 2080 and spread over the time period depending on the length of the implementation period for the measure and estimated voluntary customer participation levels.

A summary of the utility (DWU), retail customer, and total project costs each decadal year is provided in Table 7-11.

Table 7-11. Conservation Project Costs to DWU and Retail Customers

Year	DWU	Retail Customers	Total
FY 30-31	$13,082,705	$19,291,119	$32,373,824
FY 40-41	$11,563,636	$8,960,400	$20,524,036
FY 50-51	$12,429,211	$10,377,468	$22,806,679
FY 60-61	$13,285,521	$10,260,527	$23,546,048
FY 70-71	$14,179,704	$10,750,818	$24,930,522
FY 80-81	$15,300,164	$12,863,686	$28,163,849

The lifetime savings and costs to DWU and retail customers are shown in Table 7-12. DWU's total lifetime project costs are $390,752,607 while the retail customer total lifetime costs are $767,922,149. There is a positive benefit to cost ratio for both DWU and retail customers. The unit cost of water supply from implementation of conservation is $0.43/1,000 gallons.

Table 7-12. Conservation Savings Results

Lifetime Savings - Present Value ($)	
DWU	$527,204,904
Retail Customers	$1,126,796,054
Lifetime Costs - Present Value ($)	
DWU	$390,752,607
Retail Customers	$767,922,149
Benefit to Cost Ratio	
DWU	1.35
Retail Customers	1.47
Cost of Savings per Unit Volume ($/1,000 gallons)	
DWU	$0.43

7.2.4 Water Quality

Implementation of the conservation measures will not impact water quality. The water quality of the water saved due to conservation will be the same as DWU's existing water supplies.

7.2.5 Environmental Impacts

There are no environmental impacts associated with conservation. Conservation measures do not require any development of new infrastructure that may disrupt habitats, threatened or endangered species, or wetlands. There are no impacts to environmental flows or bays and estuaries because the water supply produced from conservation will come from existing supplies.

7.2.6 Confidence and Permitting

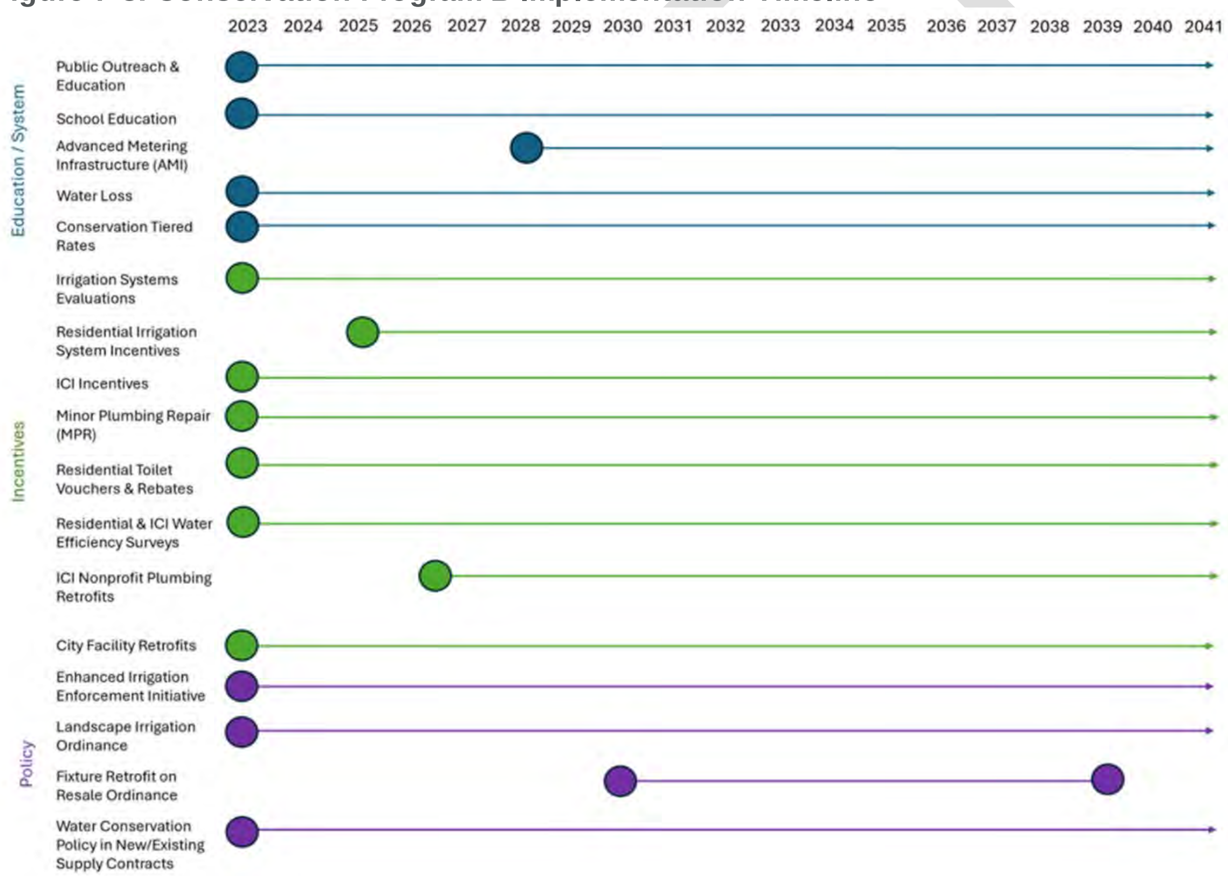
Of the 17 conservation measures included, only four of the measures are policy based, related to contract modifications, ordinances, and initiatives. Since these measures are local policy and not state required permits, minimal permitting challenges are expected. 12 of the 17 conservation measures are existing measures implemented by DWU, therefore there is high confidence that DWU will be able to implement the five additional conservation measures and work towards the maximum potential water savings.

It should be noted that reaching the maximum potential water savings of 60.5 MGD in 2080 will involve a change in customer behavior. While some of the measures may provide savings without customer participation, like city facility retrofits or advanced metering infrastructure, other measures will only be successful should customers choose to engage in the programs and abide by the ordinances in place. For example, residential toilet vouchers and rebates and residential irrigation system incentives rely on retail customers participating in the programs and spending some of their own money, as rebates often do not cover the entire project cost. It is anticipated with the implementation of multiple measures at the same time, for example public outreach and education, and conservation tiered rates or rebate programs, a change in customer behavior is more likely and may result in improved participation.

7.2.7 Flexibility and Phasing

The 17 Conservation measures were selected because several measures are currently being implemented by DWU, while the other measures could reasonably be adopted as new programs within a ten-year timeframe (by 2034). The timeline for implementation developed to help meet short-term water efficiency goals is shown in Figure 7-8.

Figure 7-8. Conservation Program B Implementation Timeline



7.2.8 Equity Impacts

Equity impacts due to implementation of conservation measures were evaluated based on the diversity, equity, and inclusions (DEI) criterion. The DEI criterion was scored on a numerical scale and then the scores were averaged to determine the DEI score for each measure. The DEI criterion is described as follows:

Diversity, Equity, and Inclusions – Considers customer equity and inclusion as well as whether one group or category of customers receives a benefit while another pays the costs (without receiving benefits). Consider commercial versus residential, income levels, renter versus owner, non-English speaking population outreach, convenience (rural, urban), economics, perceived fairness and/or aesthetics.

Diversity, Equity, and Inclusion: equitable impacts on diverse populations.

- 0 = DEI benefits (Ex. Swimming Pool covers – typically a higher income amenity)
- 3 = Minor DEI benefits (Ex. Toilet rebates – everyone has toilets, however full replacement cost not covered)
- 5 = Significant DEI benefit (Ex. Low-income direct install program, multi-family programs targeted to renters)

Since conservation is being evaluated as a single strategy, individual DEI scores for each conservation measure were compiled and categorized by the following ranges.

Table 7-13. Equity Impacts Scoring Range for Conservation

Score Range	Description	Equity Values
0 – 1	No DEI benefits	**1**
1 – 2	No/minor DEI benefits	**2**
2 – 3	Minor DEI benefits	**3**
3 – 4	Moderate DEI benefits	**4**
4 – 5	Significant DEI benefits	**5**

Measures that are existing and currently being implemented by DWU were not scored. Scores for future measures were compiled and had an average score of 2.8, indicating the potential for minor DEI benefits.

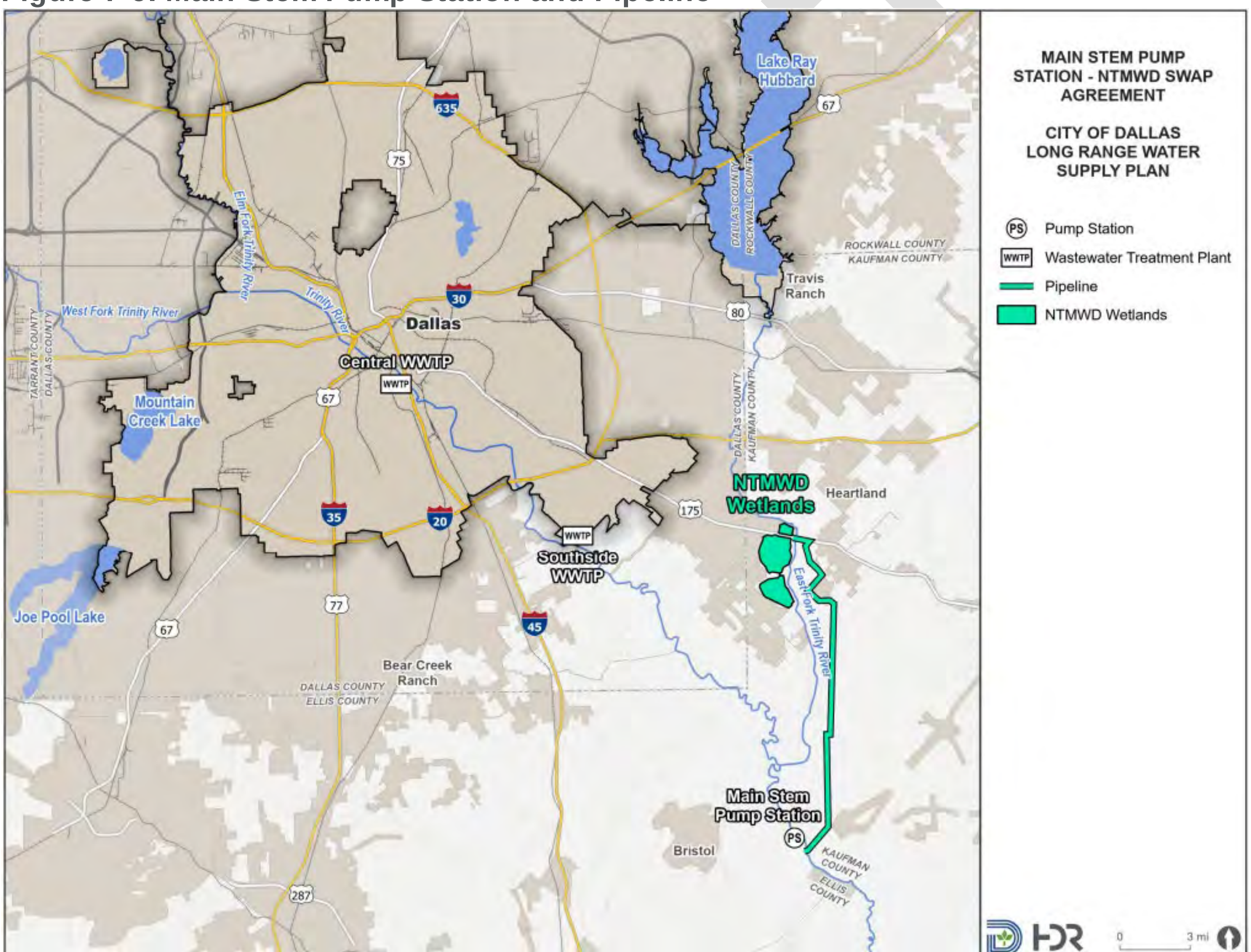
7.3 Main Stem Pump Station – NTMWD Swap Agreement

The Main Stem Pump Station (NTMWD Swap Agreement) project was a recommended strategy in the 2014 LRWSP and is a recommended water supply strategy for the 2024 LRWSP. The infrastructure portion of the project has been constructed by North Texas Municipal Water District (NTMWD) with only the execution of the swap agreement needed for completing the project. In December 2008, Dallas and the NTMWD entered into an initial agreement for the exchange of return flows. The swap agreement allows Dallas to use NTMWD return flows discharged into Lake Ray Hubbard in exchange for NTMWD utilizing a portion of Dallas' return flows from the main-stem of the Trinity River. Dallas and NTMWD cooperated in the construction of the pump station (Main Stem Pump Station) and transmission pipeline to deliver up to 90 MGD of return flows (from Dallas and other entities) from the main stem of the Trinity River to a "point of delivery" near the NTMWD wetlands located near the East Fork of the Trinity River and Hwy 175 near Seagoville. Negotiations to finalize the volumes available for the swap are nearing finalization. Once the agreement has been finalized, Dallas will have the right to utilize the agreed upon NTMWD return flows discharged into Lake Ray Hubbard for utilization within their water distribution system and no longer be required to release these flows downstream.

7.3.1 Strategy Description

The constructed project includes a main stem pump station (90 MGD) located on the Trinity River and a 72-inch diameter, 14.2 mile pipeline to transport water to the NTMWD wetlands as shown in Figure 7-9. This project provides Dallas and NTMWD the ability to swap water rights to more effectively and efficiently utilize their existing systems.

Figure 7-9. Main Stem Pump Station and Pipeline



7.3.2 Water Availability

Under the swap agreement, Dallas will exchange return flows from its Central and Southside WWTPs for an equal amount of return flows from NTMWD as discharged into Lake Ray Hubbard. Estimated yearly flows available to Dallas for this strategy during the 2025 - 2080 timeframe are shown in Table 7-14. Volumes of NTMWD return flows available to Dallas are estimated to total 37.1 MGD (41,600 acft/yr) in 2030 and 44.2 MGD (49,500 acft/yr) in 2080.

Table 7-14. Projected Average Daily Flow Exchange under Swap Agreement

Table units: MGD

Plant	2025	2030	2040	2050	2060	2070	2080
Lake Ray Hubbard Watershed							
Lake Ray Hubbard Watershed – With Water Right Permit	25.4	25.6	25.4	25.4	25.2	25.2	25.2
Potential – NTMWD Bear Creek	0.4	0.9	1.1	1.3	1.3	1.3	1.3
Lake Ray Hubbard Watershed Subtotal	25.8	26.5	26.5	26.5	26.5	26.5	26.5
Lewisville Lake Watershed							
Frisco Plants	8.4	9.3	10.8	11.7	13.0	13.8	14.7
Potential Little Elm	2.9	3.2	3.1	3.0	3.0	3.0	3.0
Lewisville Lake Watershed Subtotal	11.3	12.5	13.9	14.7	16.0	16.8	17.7
Total	**37.1**	**39.0**	**40.4**	**41.2**	**42.5**	**43.3**	**44.2**

Source 2024 North Texas Municipal Water District Long Range Water Supply Plan, excerpt from Table 3.5.

7.3.3 Flexibility/Phasing

This project takes advantage of existing infrastructure, while adding an increased volume of water creating additional resiliency within Dallas existing supplies. Construction of the project infrastructure is complete consisting of a single delivery point and intake point. The last step is refining the return flow volumes available to Dallas to finalize the swap agreement with NTMWD.

7.4 IPL Connection to Dallas System

The 2014 LRWSP identified the integrated pipeline (IPL) strategies as recommended strategies. Since that time, construction has begun on the first phase of the project which brings water from Lake Palestine into the Tarrant Regional Water District (TRWD) operated IPL. Since this portion of the project is already being implemented and under construction it is no longer considered a strategy. Phase 2 of the IPL project, bringing water into the Dallas system is still pending and has been identified as a recommended strategy for the 2024 LRWSP. What is presented here is an updated version of the IPL Phase 2 option from the 2014 LRWSP. DWU did advance the status of this project through additional feasibility studies, as recommended in the 2014 LRWSP. However, changing conditions in the DWU system have resulted in additional evaluations to be performed to verify the appropriate route to bring this into the DWU system. Future work has been proposed that would modify this strategy to potentially deliver water to a new DWU water treatment plant located in or near the southern pressure zones to meet growing demands in those zones in lieu of additional distribution system improvements. This work is expected to be completed in 2025. Regardless of the outcome, bringing Lake Palestine water into the DWU system is still a recommend strategy to complete the IPL project.

The City of Dallas and TRWD are partnering on the planning and development[6] of an integrated raw water transmission system to meet future water needs. The purpose of the transmission system is to bring water from Lake Palestine to Dallas and water from Richland-Chambers Reservoir and Cedar Creek Reservoir to TRWD in a cost-efficient way to enhance water supply reliability as demands increase. The IPL connects the Dallas and TRWD raw water transmission systems making it possible to share water resources and establish a platform for integrating future water supplies in the region. There are two components to this strategy for Dallas. The first component has been referred to as the IPL Part 1 – Connection to Palestine and the second has been referred to IPL Part 2 – Connection to the DWU system in past planning efforts. At the time of writing, IPL Part 1 is under construction and is not considered a recommended strategy but rather an existing part of the DWU system. For the purpose of the 2024 LRWSP, IPL Part 2 is all that is being considered as a recommended strategy. Moving forward, IPL Part 1 will be referred to as IPL and IPL Part 2 will be referred to as IPL Connection to the DWU System.

7.4.1 Strategy Description

TRWD will own and operate the 150.6-mile long raw water transmission pipeline which ranges in diameter from 84-inch to 108-inch and will convey water at a planned peak capacity of 347 MGD[7]. Dallas has contracted with TRWD for a portion of the capacity in the IPL. Dallas' capacity of the shared pipeline is currently planned to be 150 MGD. Dallas has contracted with Upper Neches River Municipal Water Authority (UNRMWA) for 102 MGD of Lake Palestine supply which will be conveyed through the IPL to Dallas' system. The IPL is subdivided into segments to allocate costs between TRWD and Dallas as well as to split the permitting, design, and construction into multiple packages. To provide context, Figure 7-10 shows the overall transmission system with the various classifications of the segments, either as Dallas segments, shared Dallas / TRWD segments, or TRWD segments. Figure 7-11 shows the recommended layout for bringing IPL water into the Dallas system, as provided by DWU's 2020 report from HDR.

The IPL will deliver Dallas' share of Lake Palestine water to a location near the upper end of Joe Pool Lake. From this location, Dallas will construct a delivery system to transport water to the Dallas system.

In April of 2020, HDR provided DWU with a final preliminary design report[8] outlining the IPL connection to the DWU system. The 2020 report describes the design and construction cost of a 22-mile pipeline that would connect the DWU system to the existing IPL. The 2020 study recommends conveying water to the Bachman Water Treatment Plant (WTP) and an expansion of Bachman's capacity; however, alternative

[6] Tarrant Regional Water District and City of Dallas. Integrated Pipeline Project Conceptual Design Operations Study Final Report. CDM Smith, April 20, 2012.

[7] http://www.iplproject.com/program-management/design-components/

[8] Dallas Water Utility. 2020. Final Preliminary Design Report: Integrated Pipeline (IPL) Raw Water Conveyance to the Bachman Water Treatment Plant (WTP) Study

delivery points are being considered by DWU which could result in a change from this specific strategy.

Figure 7-10. Integrated Pipeline (IPL)

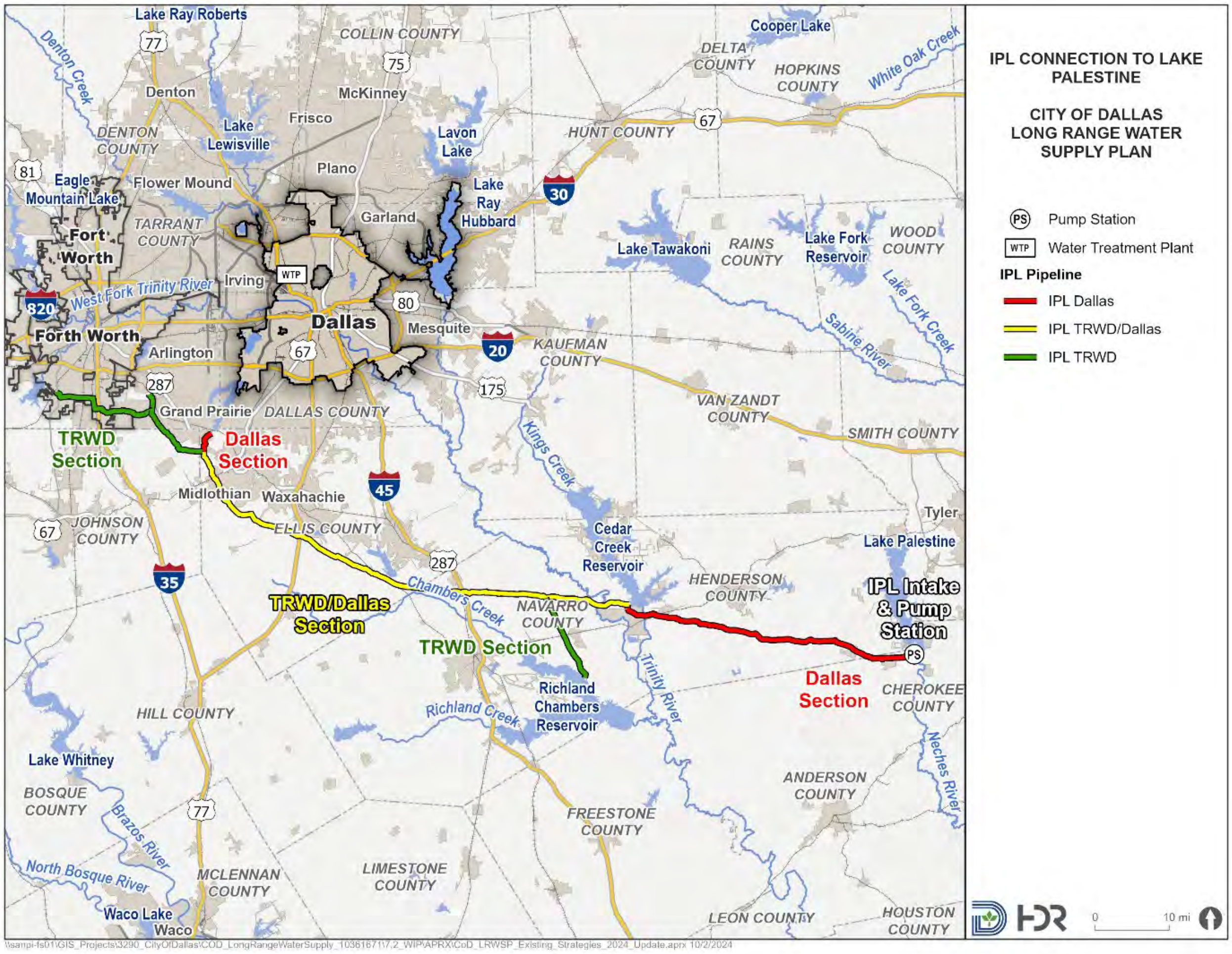
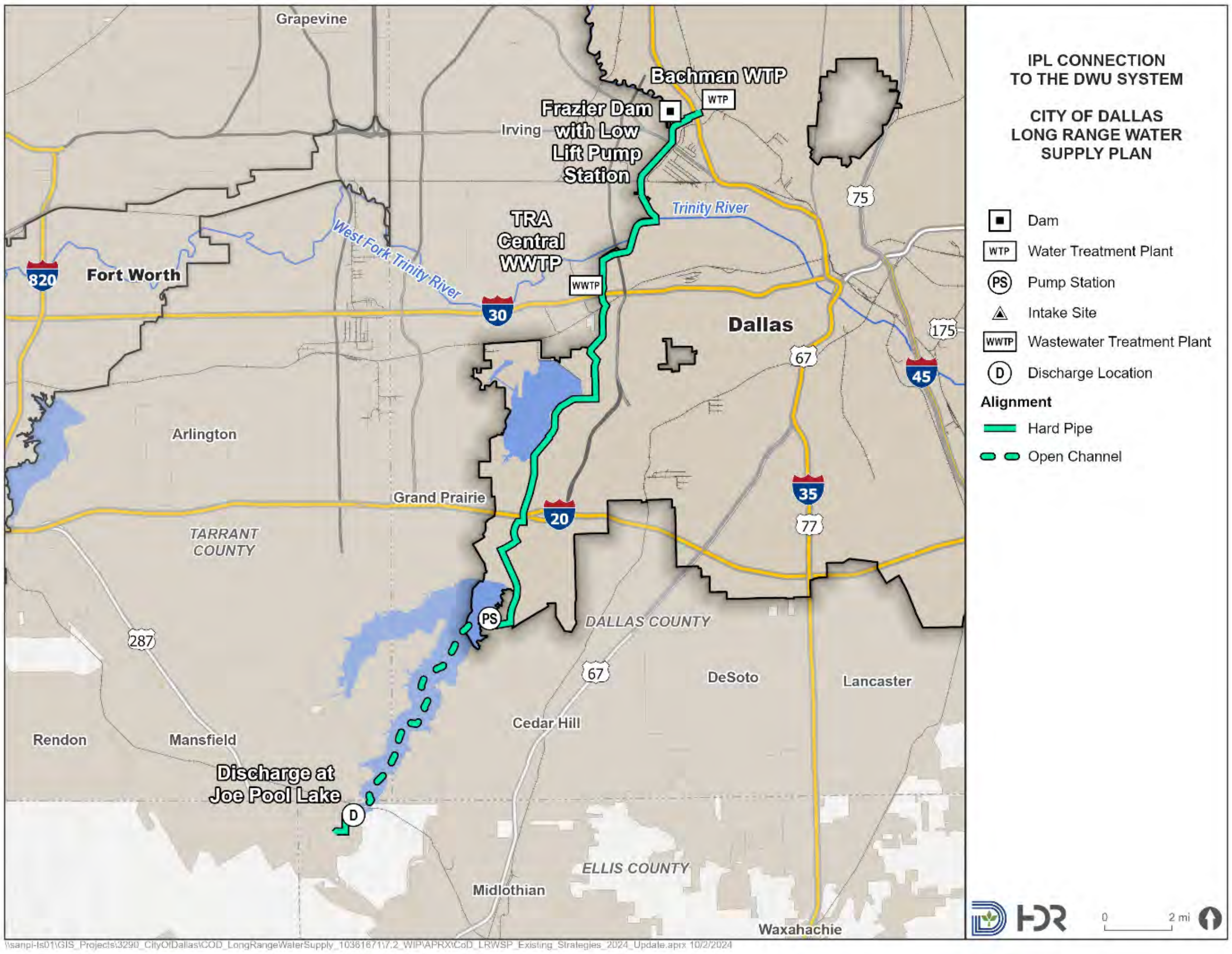


Figure 7-11. IPL Connection to the DWU System



7.4.2 Water Availability

The proposed project would carry water from the IPL transmission pipeline to the DWU system. DWU has contracted 150 MGD of transmission capacity in the IPL from TRWD. Currently, DWU plans to utilize up to 102 MGD of the capacity with water from Lake Palestine.

Water supply for DWU from the IPL will be from DWU's existing contract with the UNRMWA for Lake Palestine water. Lake Palestine is owned by the Upper Neches River Municipal Water Authority (UNRMWA) and is located on the Neches River in Henderson, Smith, Anderson, and Cherokee Counties. Deliberate impoundment began on May 1, 1962. In accordance with CoA 06-3254, the UNRMWA is authorized to store 411,840 acft and has a right to divert 212.6 MGD (238,110 acft/yr) for municipal, domestic, irrigation, and industrial uses. Additionally, UNRMWA also has the right to divert 41.1 MGD (46,000 acft/yr) from the Downstream Diversion Dam for municipal and industrial uses. UNRMWA is authorized to transfer 118.1 MGD (132,337 acft/yr) to the Trinity River Basin. Dallas is contracted with UNRMWA for 53.73% of the annual dependable yield, estimated to be 102.0 MGD (114,337 acft/yr) at the time of the contract execution, from

Lake Palestine. Lake Palestine is not currently connected to the Dallas system but needs identified in this planning study show supplies from this source could be needed by 2030.

7.4.3 Planning Cost Estimate

Costs are shown in Table 7-15 for the IPL delivery to the Dallas system to the Bachman WTP in September 2023 dollars. The unit cost to deliver Dallas' Lake Palestine supplies from the Joe Pool area to the Bachman WTP is $395 per acft or $1.21 per 1,000 gallons. After debt service, the unit cost would decrease to $34 per acft or $0.10 per 1,000 gallons. Required infrastructure includes:

- Construction of a connection to TRWD's transmission line
- Approximately one mile of 90" pipe from the IPL to the south end of Lake Joe Pool
- Sleeve valve vault and de-chlorination facility at the Lake Joe Pool outlet
- Approximately 8 miles of open channel conveyance through Lake Joe Pool
- 21 miles of 90" pipe from the north end of Lake Joe Pool to Bachman WTP
- Improvements at Bachman WTP to receive the 90" pipeline

The system will rely on residual head from the IPL and gravity, so no additional pump stations are required.

The full integration of supplies delivered through the IPL and routed to Bachman WTP into DWU distribution system will eventually require a 150 MGD WTP expansion and potentially other distribution system improvements. The costs presented in Table 7-15 do not include a 150 MGD water treatment plant expansion or an expansion of the DWU distribution system.

Table 7-15. Cost Estimate Summary for IPL Connection to the DWU System
Table units: September 2023 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Transmission Pipeline	$385,192,000
TOTAL COST OF FACILITIES	**$385,192,000**
Engineering:	$59,702,000
Legal Assistance (2%)	$6,401,000
Fiscal Services (1%)	$3,853,000
Pipeline Contingency (15%)	$57,779,000
Environmental & Archaeology Studies and Mitigation	$1,434,000
Land Acquisition and Surveying	$27,810,000
Interest During Construction (3% for 3 years with a 0.5% ROI)	$44,730,000
TOTAL COST OF PROJECT	**$586,902,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$41,194,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$3,852,000
TOTAL ANNUAL COST	**$45,046,000**
Available Project Yield (acft/yr)	114,337
Annual Cost of Water ($ per acft), based on PF=0	$394
Annual Cost of Water After Debt Service ($ per acft), based on PF=0	$33.69
Annual Cost of Water ($ per 1,000 gallons), based on PF=0	$1.21
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=0	$0.10

7.4.4 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI Database and IPaC; TPWD, TXNDD; EMST[9]; and the USGS NHD. Table 7-16 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of conditions and further study would be needed in any feasibility or permitting efforts to address potential concerns with the respective regulatory agencies. In general, the pipeline corridor does not have any major environmental issues that cannot be avoided.

7.4.4.1 HABITAT

A large portion of the proposed pipeline route follows existing road rights-of-way. Impacts to preferred habitats would be minimized by utilizing these previously disturbed areas. Wooded riparian areas commonly occur along and adjacent to stream and river crossings that would be crossed by the pipeline corridor. Additionally, undeveloped land

[9] Texas Parks and Wildlife Department. (2024). Ecological Mapping Systems – Landscape Ecology program (EMST). Retrieved from TPWD: https://tpwd.texas.gov/landwater/land/programs/landscape-ecology/ems/

east of Joe Pool Lake contains evergreen forest habitat (EMST). Wooded riparian areas are commonly utilized by many different species and should be avoided as much as reasonably possible. Pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats.

7.4.4.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the IPL Connection to the DWU System project would have no impact on daily flows in the Trinity River.

7.4.4.3 BAYS AND ESTUARIES

Similarly, the IPL Connection to the DWU System project would have a no impact on freshwater inflow to any bay or estuary system.

7.4.4.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-16 represent all species federally or state listed as threatened or endangered, and federal candidate species in the counties for which the project will be located. The project area includes 18 species that meet these criteria (IPaC and species county lists). These species would need to be considered and potentially mitigated for during project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. No designated areas of critical habitat currently occur within the project area. The listed species within the project area counties will need to be reviewed in further detail order to determine the feasibility of the project.

7.4.4.5 WETLANDS

Although a number of NWI-identified wetlands occur along the proposed pipeline corridor, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas. Impacts to wetlands associated with this project are anticipated to be low.

7.4.4.6 AGRICULTURAL AND NATURAL RESOURCES

The IPL Connection to the DWU System project is not anticipated to impact any significant agricultural resources as the project is primarily situated in an urban environment. There are no agricultural land uses along the project route downstream of Joe Pool. There is a small amount of agricultural cultivation land use at the upper end of Joe Pool Lake where this project is expected to connect with the IPL from Palestine. It is possible that some agricultural activities within these areas may be disturbed during pipeline construction. However, because these areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources.

Table 7-16. Environmental Factors for IPL Connection to the DWU System

Environmental Factors	Comment(s)
Habitat	No presence of critical or unique habitat in project area. Low to Medium Impact
Environmental Water Needs	Low Impact
Bays and Estuaries	Low Impact
Threatened and Endangered Species	Tricolored bat (FPE), golden-cheeked warbler (FE), piping plover (FT, ST), Rufa red knot (FT, ST), whooping crane (FE, SE), alligator snapping turtle (FPT), monarch butterfly (C), white-faced ibis (ST), wood stork (ST), black rail (ST), black bear (ST), alligator snapping turtle (ST), Texas horned lizard (ST), sandbank pocketbook (ST), Louisiana pigtoe (ST), Texas heelsplitter (ST), Trinity pigtoe (ST), Texas fawnsfoot (ST) Low to Medium Impact
Wetlands	Potential for wetlands along pipeline site. Low to Medium Impact

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened.
C = Candidate for Federal Listing. Source: USFWS, 2024 and TPWD 2024

7.4.5 Water Quality

Lake Palestine is on the TCEQ 303(d) list for depressed levels of dissolved Oxygen and for pH impairments. Lake Joe Pool also causes some concern with high levels of Bromide and Manganese. These water quality issues are common and both Lake Palestine and Joe pool are currently treated to EPA standards by DWU or other entities. The 2020 DWU report from HDR recommends additional pre-oxidant for manganese removal and modifications to Bachman WTP's ozone treatment procedure for the removal of MIB and Geosmin[10].

7.4.6 Confidence and Permitting

The IPL Connection to the DWU System project could pose several permitting challenges along with the typical challenges associated with a new project. Detailed information on permitting and environmental concerns was compiled by HDR in 2020 for DWU's "Final Preliminary Design Report: Integrated Pipeline (IPL) Raw Water Conveyance to the Bachman Water Treatment Plant (WTP) Study," and this information is provided in Table 7-17. To summarize, a Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the pipeline if there are impacts within a jurisdictional water. A Section 408 permit from the USACE will likely be required for construction activities near a levee. The Section 408 permit could be a significant permitting obstacle to be overcome.

The conservation pool of Joe Pool Lake is owned by the USACE and is regulated by the USACE in coordination with the TRA under TRA's state water rights permit. Coordination will be necessary with the USACE and TRA to allow Dallas to temporarily store water in

[10] Dallas Water Utility. 2020. Final Preliminary Design Report: Integrated Pipeline (IPL) Raw Water Conveyance to the Bachman Water Treatment Plant (WTP) Study

Joe Pool Lake. Coordination with TPWD is necessary to obtain permission to cross Cedar Hill State Park, outside of existing easements. A new easement agreement may be required with TPWD or Dallas County (property owner). The Wildlife Habitat Assessment Project Review will occur during the EA process, unless no EA is required, then the project review will occur independently. TPWD will likely require BMPs for construction and maintenance activities.

Table 7-17. Potential Permitting Requirements[11]

Permitting Concerns	Permitting Trigger	Agency Coordination	Description of Coordination/Planning/Permitting Documentation to Meet Permitting Requirements
Section 408 Permission / NEPA documentation, likely an Environmental Assessment (EA)	Use/alteration of a USACE civil works project, Trinity River Floodplain/levees and discharge at Joe Pool Lake	USACE/Non-federal project sponsor	Coordination with USACE and DWU (non-federal sponsor) and submittal of Section 408 authorization request. Supporting documentation for the authorization request includes a review of project compliance with USACE construction standards, geotechnical report, levee stability and seepage analysis, and a hydraulics and hydrology system performance analysis. The supporting studies/reports must be completed prior to submittal of the request. The proposed project may not meet the criteria for coverage under the Programmatic Environmental Assessment for Minor Section 408 Requests (USACE 2011). Therefore, a standalone Environmental Assessment (EA) may be required. a) An EA requires evaluation and documentation of the project's effect on existing resources in the project area b) An EA often requires public involvement in the form of a public comment period, public meeting, or public hearing **Note:** Section 408 Authorization required before the Section 404/Section 10 permit can be issued.
			If the USACE-Fort Worth District Engineer and/or Southwest Division determines the project requires authorization from USACE-HQ, then an Environmental Impact Statement (EIS) and USACE-HQ decision may be required.
CWA Section 404 Permit (Nationwide Permit [NWP] 12 with Pre-construction Notification [PCN] or Individual Permit [IP])	Jurisdictional stream/wetland fill and outfall structures within jurisdictional areas	USACE	Conduct waters of the U.S. delineation in accordance with USACE guidelines; develop/implement avoidance and minimization measures to reduce impacts within threshold for a NWP 12 (if possible): a) Review project compliance with General Conditions and conduct appropriate additional studies needed to confirm compliance (e.g. cultural resource review, threatened and endangered species review, etc.) b) Prepare a Pre-construction Notification (PCN), including detailed documentation of alternatives analysis **Note:** NWP 12 requires a PCN when a Section 10 Permit is required, when there will be mechanized clearing of a forested wetland, and when a utility line runs parallel to a jurisdictional stream
			If impacts exceed 0.5 acres of loss to a water after avoidance and minimization, an Individual Permit (IP) may be required: a) Develop detailed documentation of alternatives analysis to satisfy 404(b)(1) requirements b) Develop a mitigation plan for unavoidable impacts to jurisdictional features

[11] Dallas Water Utility. 2020. Final Preliminary Design Report: Integrated Pipeline (IPL) Raw Water Conveyance to the Bachman Water Treatment Plant (WTP) Study

Permitting Concerns	Permitting Trigger	Agency Coordination	Description of Coordination/Planning/Permitting Documentation to Meet Permitting Requirements
Rivers and Harbors Act Section 10	Crossing under the Trinity River, a designated Section 10 – navigable water	USACE	Typically completed concurrent with Section 404 permit
Texas Parks and Wildlife Department Coordination	Crossing State Park	TPWD	Coordination with TPWD to obtain permission to develop on new ground and within existing easements within Cedar Hill State Park, under Texas Natural Resource Code, Chapter 26: a) May require Wildlife Habitat Assessment Program project review b) Likely will require Best Management Practices (BMPs) to be implemented to reduce adverse effects to wildlife and plants within Park (e.g., trenchless segments)
Escarpment Permit	Crossing small portion of Escarpment Zone, along the east side of Mountain Creek Lake	City of Dallas	A pre-application conference with the escarpment area review committee to determine necessary analysis for permit application. These may include 1) slope stability analysis, 2) soil erosion control plan, 3) grading plan, and 4) vegetation plan. Plan and cross sections of the project within the Geologically Similar Area must be available for review. Once all required analyses are complete, submit the application with appropriate supporting information.
Trinity River and Tributaries Regional EIS Conformity Trinity River Corridor Development Certificate	Development within the Trinity River Corridor	NCTCOG	Submit Corridor Development Certificate application, including a hydraulic model of floodplain elevations with the project. Multiple concurrent agency reviews required, including the USACE, FEMA, and TCEQ, as well as municipalities within the Corridor.
TCEQ Bed and Banks Authorization	Conveying water through a state watercourse	TCEQ	Pre-application meeting with the TCEQ to discuss the project and need for a water right permit. Preparation and submittal of the application, supplemental information document (SID), and other items required in the application package. Address any administrative and technical TCEQ requests for information (RFI). Develop an accounting plan in Excel spreadsheet format to document daily IPL water discharges, diversions, and losses associated with the water right. Meet with potential protestant(s) to address and reconcile any concerns in an attempt to avoid a contested case hearing at the State Office of Administrative Hearings. Participation in a contested case hearing if protestant(s) concerns cannot be reconciled. Upon granting of the permit from the TCEQ, file the final permit at the appropriate county office in Dallas County.

Permitting Concerns	Permitting Trigger	Agency Coordination	Description of Coordination/Planning/Permitting Documentation to Meet Permitting Requirements
USACE Operations and Real Estate Coordination	Within USACE property; intake located near designated environmentally sensitive area	USACE	1) Coordination with USACE-Lake Operations to obtain permission to cross USACE property and utilize the Joe Pool as a conveyance. 2) Coordination with USACE-Lake Operations to construct intake near designated environmentally sensitive areas (areas where scientific, ecological, cultural or aesthetic features have been identified). The USACE must determine that the proposed project will not adversely impact any environmentally sensitive area. a) Will require a footprint of the proposed intake facility and sufficient operational details to determine the effects to environmentally sensitive areas b. Conducted concurrently with Section 408 review and Real Estate concurrence must be received prior to 408 Permission

7.4.7 Flexibility and Phasing

IPL Connection to the DWU System is susceptible to permitting risk particularly associated with delivery from the Joe Pool Lake area to the Bachman WTP. The potential pipeline corridor is highly developed and would require significant coordination for construction activities. The 2020 HDR report for DWU recommends a three-phase construction sequence for the project. Additional opportunities exist as mentioned previously to deliver water to alternative WTP sites if needed. Supply for the IPL is sourced from a reliable reservoir which should contribute to additional drought resiliency for the strategy.

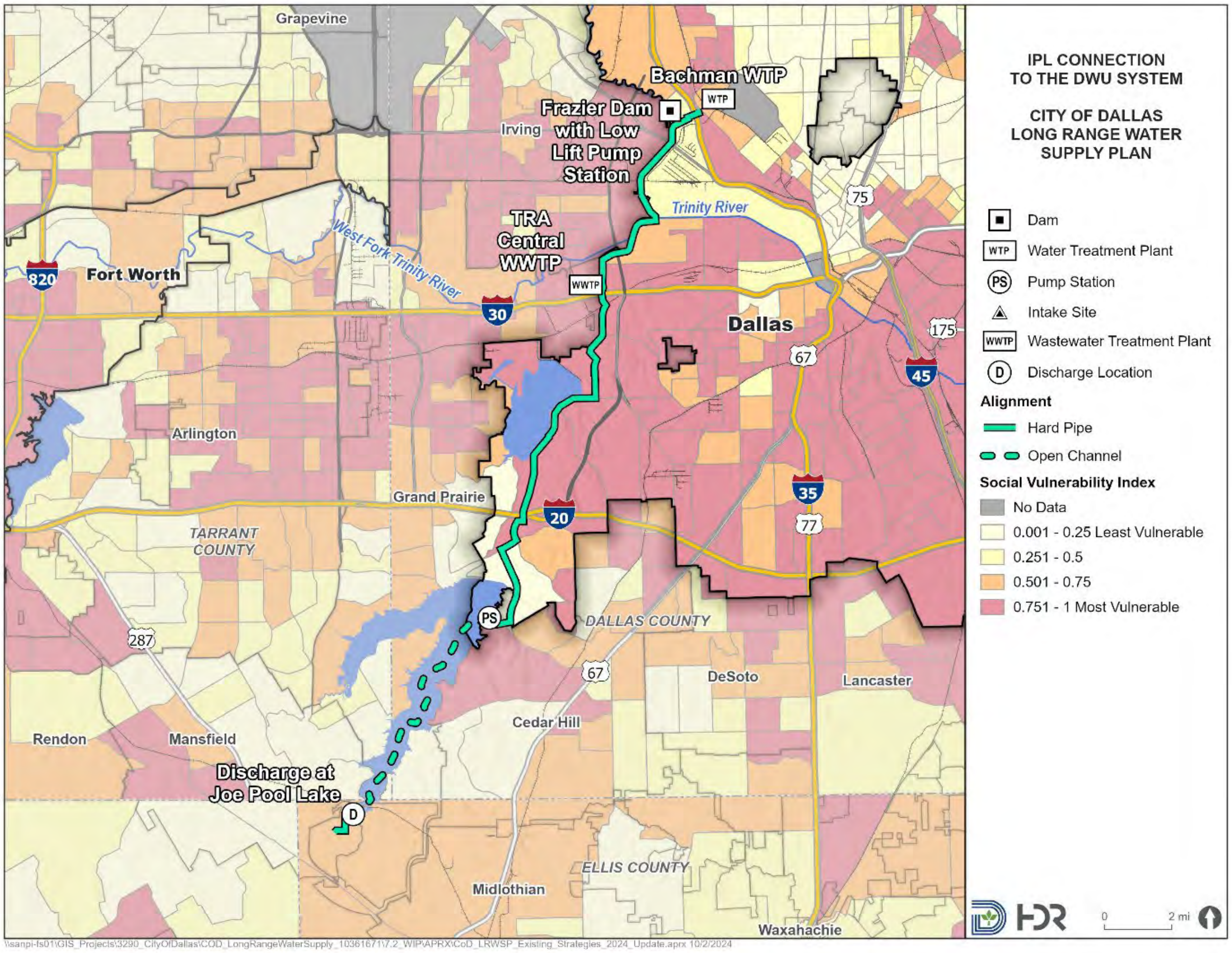
7.4.8 Equity Impacts

The impacts from the IPL Connection to the DWU System project are due to the installation of a transmission pipeline from Joe Pool Lake to Bachman WTP or a new WTP. At the time of writing, no new WTPs are included in the scope of this analysis, so equity impacts will be determined for the pipeline footprint from the IPL to Joe Pool and from Joe Pool to Bachman WTP. Table 7-18 reports the percentage of each SVI quartile impacted by the project's footprint. Figure 7-12 shows the preliminary outline of the project. The low equity score of 1 is due to the majority of the project taking place in census tracts with a high SVI. This does not consider the type of impact the project will have on that community. The project is a pipeline that will be built primarily in existing rights-of-way where possible, which should limit its impact on the surrounding communities. It also will be a temporary impact to some degree, as once the pipeline is built, some activities can resume in the right-of-way.

Table 7-18. IPL Connection to the DWU System Equity Impact by CDC SVI Quartile

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
6.6%	5.0%	4.9%	83.6%	1

Figure 7-12. IPL Connection to the DWU System Equity Impact by CDC SVI Quartile



7.5 Main Stem Balancing Reservoir

The Main Stem Balancing Reservoir was a recommended strategy in the 2014 LRWSP. After reevaluation, this strategy has again been designated as a recommended strategy in the 2024 LRWSP

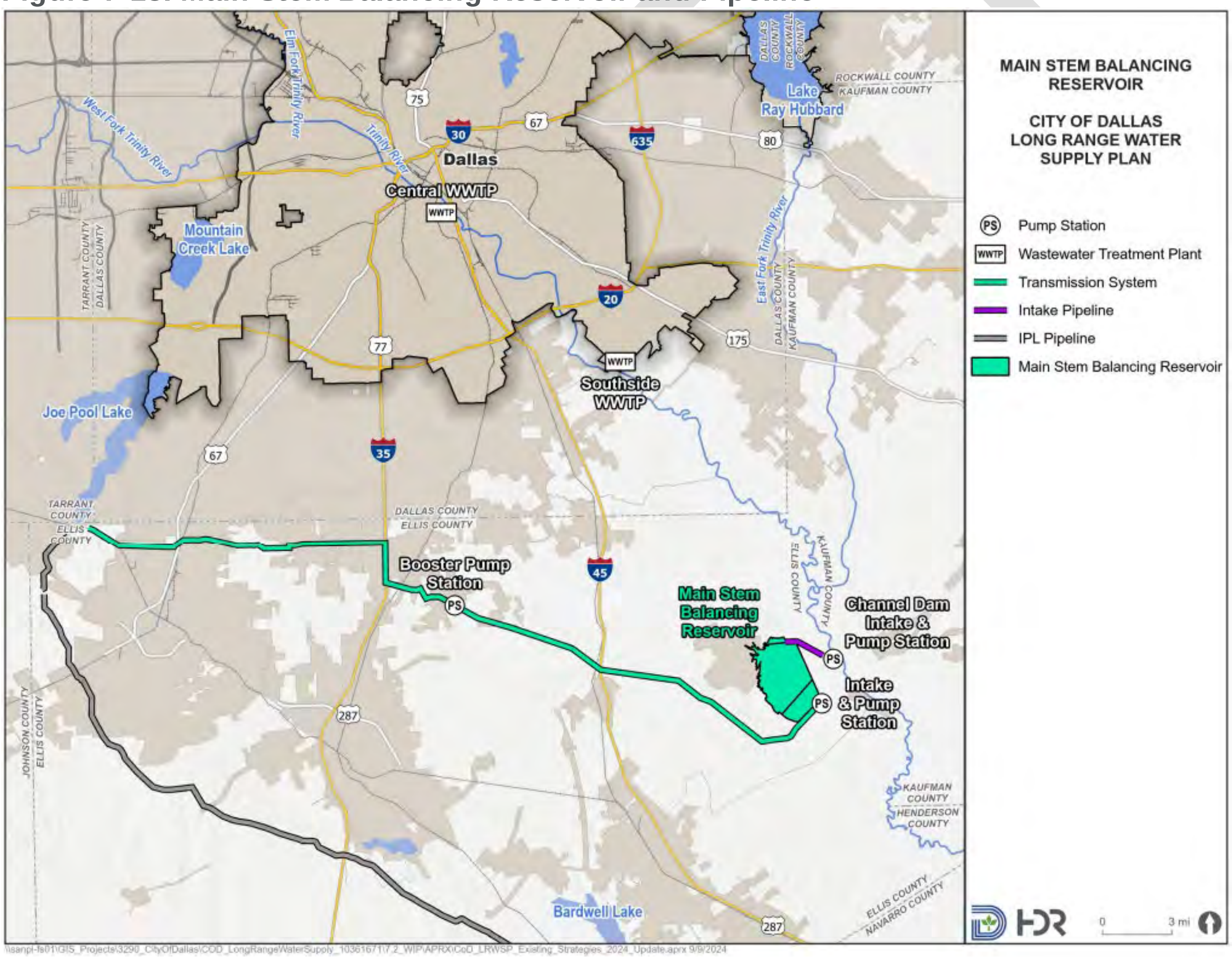
The DWU 1975 Long Range Water Supply Plan identified a 64,000 acft balancing reservoir in Ellis County southeast of Bristol as a potential delivery location for water from the proposed Tennessee Colony Reservoir. For the 2024 LRWSP the same site was identified as the Main Stem Balancing Reservoir, a proposed off channel reservoir (OCR) that could store approximately 300,000 acft. This site is shown in Figure 7-13 and could store Dallas' (and potentially other entities') return flows as well as stormwater runoff originating in the upstream Trinity River watershed. Additionally, because the diversion location for this strategy is located downstream of the confluence with the East Fork of the Trinity River (East Fork), the Main Stem Balancing Reservoir could also be used to transfer water from Dallas' eastern system to Dallas' western system by storing water released from either Lake Ray Hubbard or from Dallas' eastern raw water transmission pipelines where they cross the East Fork.

7.5.1 Strategy Description

Dallas has secured water rights to use return flows from its Central and Southside wastewater treatment plants. This reuse water is a valuable asset that can be utilized by Dallas and does not require additional appropriation of state water.

The storage of return flows in the balancing reservoir provides several benefits including water quality benefits and the benefit of being able to store the water during times of plenty and diverting it for subsequent use during times of drought. Figure 7-13 provides the location of the Main Stem Balancing Reservoir and diversion site from the Trinity River. For this strategy evaluation water supplies are shown delivered to the Joe Pool Lake area through a 36.5 mile transmission system. However, there are many different potential configurations of this project described in the flexibility and phasing subsection that require additional study to determine the best benefit for Dallas.

Figure 7-13. Main Stem Balancing Reservoir and Pipeline



7.5.2 Water Availability

The Main Stem Balancing Reservoir was preliminarily configured to achieve a desired firm yield of 102 MGD (114,000 acft/yr) by 2070 in the 2014 LRWSP. The water availability analysis for the 2024 LRWSP indicates that by 2060 more than the 102 MGD of return flows would be available for diversion after considering the swap agreement with NTMWD and an amended instream flow requirement associated with Dallas' return flow permit (12468) as shown in Table 7-19. As discussed in the Flexibility and Phasing Subsection, there are other options for increasing the availability of this project by utilizing additional sources which would increase the project yield.

Table 7-19 Summary of Available Return Flows from Dallas WWTPs

Criteria	2030	2040	2050	2060	2070	2080
Dallas Return Flows considering conservation (dry conditions) (MGD)	182	199	216	233	250	267
Amended Instream Flow Requirement (MGD)	(74)	(74)	(74)	(74)	(74)	(74)
NTMWD Swap Agreement (MGD)	(39.0	(40.4)	(41.2)	(42.5)	(43.3)	(44.2)
Available Return Flows (MGD)	69	84.6	100.8	116.5	132.7	148.8

7.5.3 Project Cost Estimate

Infrastructure required for the Main Stem Balancing Reservoir include a potential channel dam on the Trinity River, a 127.5 MGD intake and pump station and a 72-inch diameter pipeline to convey available flows to the reservoir. The off channel reservoir will be formed by an embankment that is approximately 6 miles in length and 90 feet high at the highest point. The Balancing Reservoir includes a sedimentation basin so that suspended sediments will settle and accumulate for periodic removal. Stored water would be diverted from the reservoir though an intake and pump station and delivered to the Joe Pool Lake area through a 90-inch diameter, 36.5-mile pipeline.

A summary of the project and annual costs for the Main Stem Balancing Reservoir strategy with delivery to the Joe Pool Lake area is listed in Table 7-20. Total project costs are $1,767,099,000. Annual costs for the project assume a 40-year debt service with a 3.5 percent interest rate and are estimated to be $138,223,000 per year. The unit cost of water for this project to deliver water to the Joe Pool area would be about $1,209 per acft or $3.71 per 1,000 gallons. After debt service, the unit cost of water is decreased to $234 per acft or $0.72 per 1,000 gallons.

Table 7-20. Cost Estimate Summary for Main Stem Balancing Reservoir Project
Table units: September 2023 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Storage/Ring Dike (Conservation Pool 300000 acft, 4337 acres)	$282,129,000
Intake Pump Stations (127.5 MGD)	$127,285,000
Transmission Pipeline (72-90 in. dia., 38.3 miles)	$642,549,000
Transmission Pump Station(s) & Storage Tank(s)	$75,339,000
Integration, Relocations, Backup Generator & Other	$15,652,000
TOTAL COST OF FACILITIES	$1,142,954,000
OTHER PROJECT COSTS	
Engineering:	
- Planning (3%)	$34,289,000
- Design (7%)	$80,007,000
- Construction Engineering (1%)	$11,430,000
Legal Assistance (2%)	$22,859,000
Fiscal Services (2%)	$22,859,000
Pipeline Contingency (15%)	$96,274,000
All Other Facilities Contingency (20%)	$100,225,000
Environmental & Archaeology Studies and Mitigation	$48,977,000
Land Acquisition and Surveying (4584 acres)	$50,910,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$156,315,000
TOTAL COST OF PROJECT	**$1,767,099,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$87,010,000
Reservoir Debt Service (3.5 percent, 40 years)	$24,487,000
Operation and Maintenance	x
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$6,796,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$4,529,000
Dam and Reservoir (1.5% of Cost of Facilities)	$4,232,000
Pumping Energy Costs 0.09 $/kW-hr)	$11,169,000
TOTAL ANNUAL COST	**$138,223,000**
Available Project Yield (acft/yr)	114,337
Annual Cost of Water ($ per acft), based on PF=1.25	$1,209
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.25	$234
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.25	$3.71
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.25	$0.72

7.5.4 Water Quality

There are some water quality concerns with the Main Stain Balancing Reservoir strategy. The Trinity River is on the TCEQ 303(d) list of dioxins, Polychlorinated Biphenyls (PCBs), and Bacteria. Further, there may be PFAS contamination in the Dallas-Fort Worth area. The project's water quality risks could be mitigated through blending with other DWU sources and by operating the reservoir to maintain adequate residence time to allow natural processes to enhance water quality, and by the addition of mixing units at the reservoir to reduce stratification. While not anticipated to be required at this time, land for potential future wetlands for treatment has been included in the project cost estimate.

7.5.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[12] and IPaC[13]; TPWD TXNDD[14] and county species lists[15]; and the USGS NHD[16]. Table 7-21 provides a summary of known environmental factors that would need to be considered during the permitting of this project. These categories provide a general summary of conditions and further study would be needed during permitting to address potential concerns with the respective regulatory agencies.

7.5.5.1 HABITAT

The footprint of the reservoir occurs within an area of developed agricultural land in the Trinity River floodplain. The pipeline route crosses agricultural areas. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that would be crossed by the pipeline corridor. Wooded areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route also crosses wetland areas, as identified on the NWI, which could be disturbed by construction activities. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities will help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing habitat are anticipated to be low.

---

[12] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[13] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[14] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[15] Texas Parks and Wildlife Department. (2024). Rare, Threatened, and Endangered Species of Texas (RTEST). Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[16] US Geological Survey. (2019). National Hydrography Dataset. Retrieved from ESRI.

7.5.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Main Stem Balancing Reservoir will have a very limited impact on daily flows in the Trinity River since it would rely on permitted return flows and would leave adequate flows in the Trinity River to meet TCEQ environmental flow standards.

7.5.5.3 BAYS AND ESTUARIES

The Main Stem Balancing Reservoir would not be expected to impact freshwater inflow into Trinity Bay since the strategy would rely on permitted return flows and will leave adequate flows in the Trinity River to meet TCEQ environmental flow standards.

7.5.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-21 represent all species federally or state listed as threatened or endangered, and federal candidate species in the county for which the project would be located. The project area includes 25 species that meet these criteria (IPaC and county species list). These species would need to be considered and potentially mitigated for during project permitting and implementation. Siting of the pipelines to avoid specific habitat types during design and the use of BMPs during construction would be anticipated to minimize potential impacts to species within the project area. The numbers of listed species which occur within the project area counties are not expected to present a significant challenge to the feasibility of the project. This project area crosses the Sabine River and the Trinity River which have been designated as proposed critical habitat for the proposed endangered Texas heelsplitter. The listed species within the project area counties will need to be reviewed in further detail order to determine the feasibility of the project.

7.5.5.5 WETLANDS

Review of available mapping of the reservoir footprint indicates minimal wetland acreage would be affected by the project. To the extent wetlands are located at the site; they would be mitigated in accordance with required federal regulations as administered through the USACE Section 404 permitting process.

Although several wetlands occur along the proposed pipeline corridor flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas.

7.5.5.6 AGRICULTURAL AND NATURAL RESOURCES

The project Balancing Reservoir site would permanently impact an estimated 2,140 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils. This area represents less than 1% of the Ellis County prime farmland. Construction activities associated with the project pipeline would impact an additional 120 acres of prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the other Environmental Impacts sections above.

Table 7-21. Environmental Factors for Main Stem Balancing Reservoir Project

Environmental Factors	Comment(s)
Habitat	Blackland prairie and post oak Savannah ecoregions Medium Impact
Environmental Water Needs	Previously permitted return flows Low Impact
Bays and Estuaries	Previously permitted return flows Low Impact
Threatened and Endangered Species	Tricolored bat (PE), golden–cheeked warbler (FE), piping plover (FT, ST), rufa red knot (FT, ST), whooping crane (FE, SE), alligator snapping turtle (FPT, ST), Louisiana pigtoe (PT, ST), Texas fawnsfoot (FT, ST), Texas heelsplitter (PE), monarch butterfly (C), Trinity pigtoe (ST), Texas horned lizard (ST), black rail (FT, ST), wood stork (ST), southern hickorynut (ST), sandbank pocketbook (ST), Louisiana pine snake (FT, ST), northern scarlet snake (ST), Louisiana black bear (ST), black bear (ST), western creek chubsucker (ST), Bachman's sparrow (ST), swallow-tailed kite (ST), white-faced ibis (ST), whooping crane (FE). There is proposed critical habitat for the Texas heelsplitter within the project area. Medium Impact
Wetlands	Minimal impacts to wetland would be expected. Low Impact
Agriculture and Natural Resources	2,140 acres of prime farmland soils impacted by Balancing Reservoir which make up less than 1% of the Ellis County prime farmland. Low Impact

Source: USFWS, 2024 and TPWD 2024
FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened.
C = Candidate for Federal Listing.

7.5.6 Confidence and Permitting

The Main Stem Balancing Reservoir project would pose some permitting challenges along with the typical challenges associated with a new project (Table 7-22). Similar to other new water projects in Texas, a surface water permit for the channel dam (if needed) on the Trinity River would be required from TCEQ. While Dallas has rights to divert its Trinity River discharges, a new water right permit would be required to divert stormwater. In addition to the surface water permit, a Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the diversion facilities and pipeline. While yield analyses did not indicate any impacts to the firm yield of downstream reservoirs; a subordination agreement may be necessary for the diversion of stormwater.

Table 7-22. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right and Storage Permit	TCEQ	Dallas has rights to divert its wastewater discharges but will need additional permits to store water in the Balancing Reservoir and channel dam.
Section 404	USACE	Required for construction activities in waters of the US.

7.5.7 Flexibility and Phasing

This project carries a high degree of flexibility. For example, the source water for this evaluation is Dallas' own effluent, but this could be expanded to include unappropriated stormwater, other entities return flows, or even Dallas' existing water right authorizations moved to this location. The delivery location also has a degree of flexibility with delivery to the east subsystem just as feasible as delivery to the west. This project could also be incorporated into the IPL project as a balancing reservoir as the IPL pipelines are less than 15 miles from the project site. This strategy is also situated so that there are several potential regional cooperation opportunities that could include trades of this water with other regional providers in exchange for water delivered to Dallas' western system. This particular strategy could become a valuable asset to the Dallas water supply portfolio relying on the unique site characteristics and flexible configurations.

While this the Main Stem Balancing Reservoir strategy is highly flexible, the flexibility of the strategy is limited by performance risk associated with availability of return flows, water quality considerations and required environmental flows.

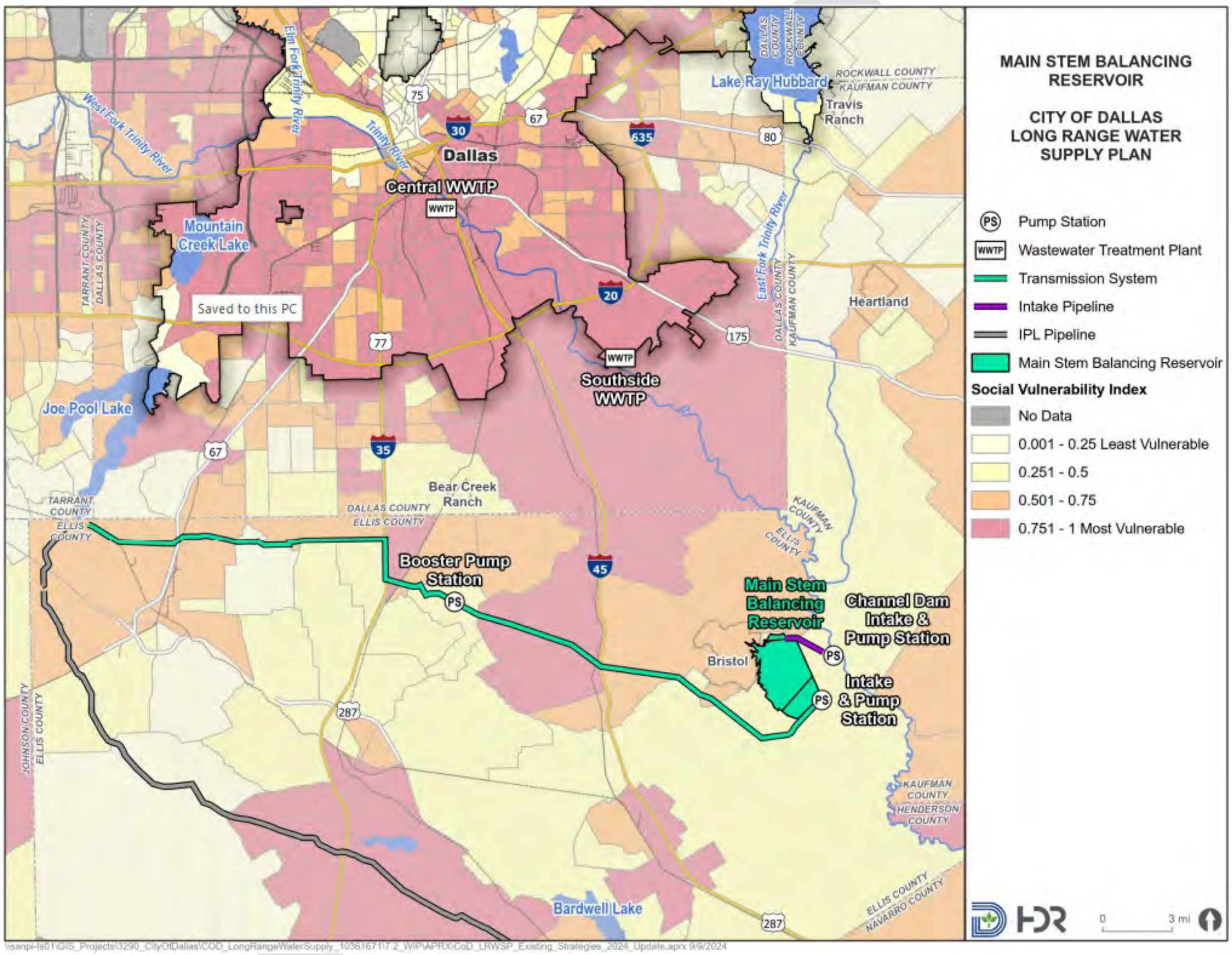
7.5.8 Equity Impacts

Impacts to equity from implementation of the Main Stem Balancing Reservoir may result from placement of potential project infrastructure such as the reservoir, transmission pipelines, and pump stations. Equity was evaluated by looking at the percent area of project components located within each quartile of the CDC's Social Vulnerability Index. (see Table 7-23 and Figure 7-14). Almost all of the project infrastructure, including the reservoir and intake pipeline is located in the 2^{nd} quartile of the CDC's SVI, which means that most of the project infrastructure is located outside of areas most likely to experience significant equity impacts

Table 7-23. Main Stem Pump Station SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
0.2%	94.0%	4.9%	0.9%	**3**

Figure 7-14. Main Stem Balancing Reservoir Project Infrastructure in Relation to the CDC's SVI



7.6 Sabine Conjunctive Use

The Sabine Conjunctive Use strategy has been recommended by the 2024 LRWSP as a two-phase project. The first phase of the project is the Carrizo-Wilcox Groundwater project from the 2014 LRWSP, and the second phase of the project is the Sabine River Off-Channel Reservoir. The completion of both phases results in the Sabine Conjunctive Use strategy from the 2014 LRWSP and now 2024 LRWSP.

The Sabine conjunctive use project combines groundwater supplies from the Carrizo-Wilcox and Queen City aquifers with an off-channel reservoir (OCR) in Smith County that impounds surface water diverted from the Sabine River. The combination of the two projects has the potential to provide a significantly larger volume of water to DWU than the yields of the stand-alone projects. Conjunctive use is defined as the use of two varied projects (in this case groundwater and surface water with an off-channel reservoir scalping run of the river flows) to achieve a greater yield as a combined project than as two stand-alone projects.

7.6.1 Part 1 – Carrizo-Wilcox Groundwater

Based on current and future estimates of groundwater use within Wood, Upshur and Smith counties there is sufficient available groundwater with good water quality that could be developed by Dallas to meet long term water demands. An initial estimate of potentially available groundwater was determined by comparing projected groundwater demands in these counties to modeled available groundwater (MAG) amounts developed by the TWDB for each county. The results of that analysis indicated that up to 90 MGD (101,358 acft/yr) of groundwater is potentially available for development in the Carrizo-Wilcox and the Queen City aquifers in the three counties. These counties are located east of Lake Fork where Dallas has recently installed the new Lake Fork Pump Station and transmission system which has the capacity to transfer 212 MGD to the Lake Tawakoni area. Considering that the estimated 2080 firm yield of Lake Fork available to Dallas is about 90 MGD, there is currently about 122 MGD of available capacity for additional water supplies in the Lake Fork transmission system. The planned 144-inch diameter pipeline from Lake Tawakoni to the Eastside WTP will have an available excess capacity of 216 MGD, once constructed. The transmission systems on Dallas eastside subsystem will be more than adequate to deliver this water to Dallas.

7.6.1.1 STRATEGY DESCRIPTION

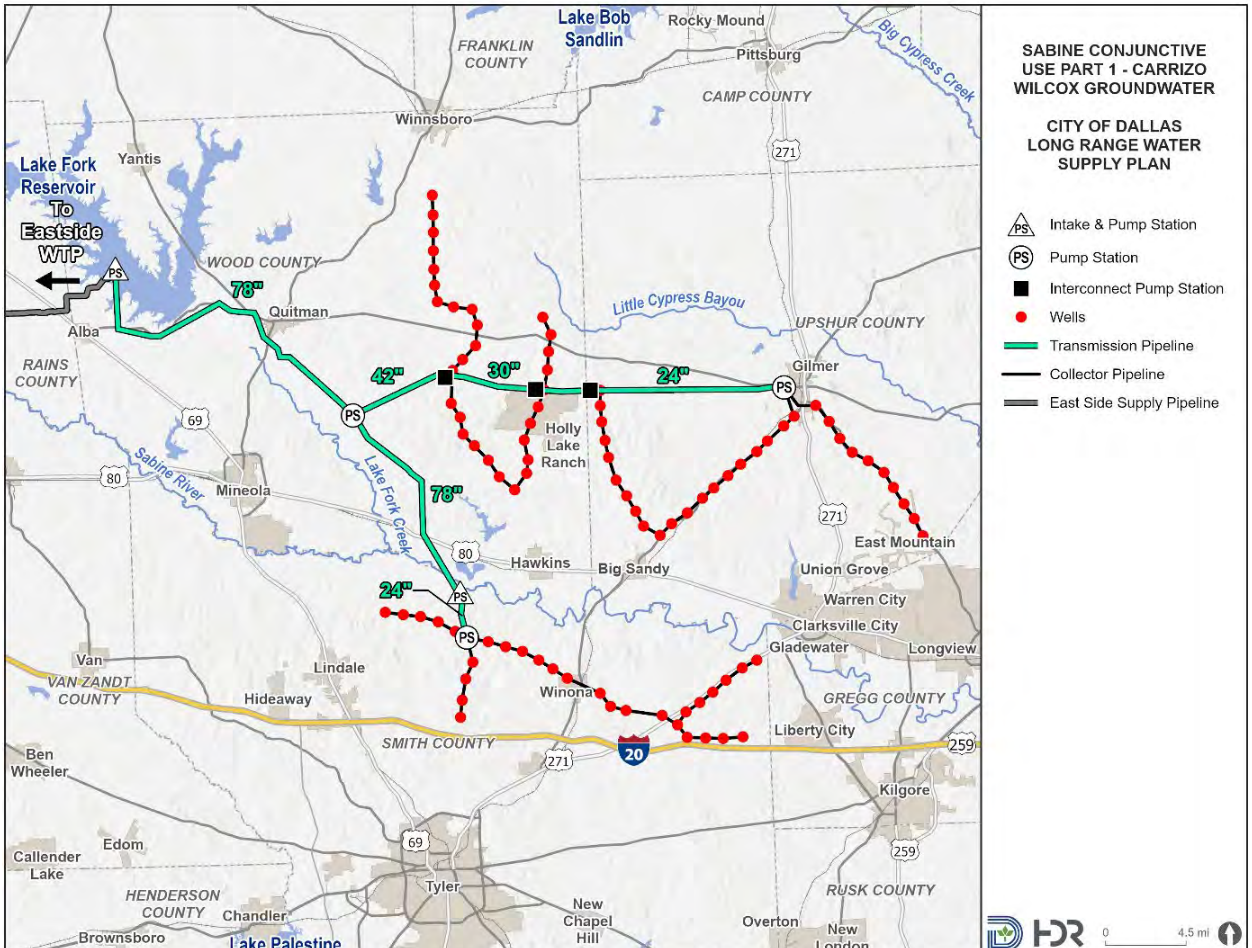
The Carrizo-Wilcox Groundwater strategy (Groundwater project) will provide 27 MGD (30,000 acft/yr) of new supply using new well fields in Wood, Upshur and Smith counties. Many of the wells will be co-located on the same site to produce groundwater from both the Carrizo-Wilcox and Queen City aquifers.

The Carrizo Formation is composed of relatively permeable sandstone about 100 to 200 feet thick. The underlying Wilcox Group has a maximum thickness of about 1,000 feet and consists of a sequence of interbedded sand, silt, clay, and some lignite. Well yields for the Carrizo Formation and Wilcox Group are estimated to average 450 gpm (0.65 MGD) per well with well depths in the study area ranging between 500 and 1,100 feet. The water quality in the Carrizo and Wilcox is very good.

The Queen City Aquifer is composed of fluvial to deltaic sand deposits which outcrop over much of the area, which means a thinner saturated thickness and a reduction in well yields. Well yields for the Queen City aquifer are estimated to average 150 gpm (0.22 MGD) with typical well depths in the study area ranging between 200 and 400 feet.

Figure 7-15 provides the locations of the well fields, transmission pipelines and pump stations for this strategy. The well fields have a combined maximum pumping capacity of 27 MGD (30,000 acft/yr). Groundwater from the well fields is pumped through a 58 mile transmission system to the existing intake and pump station at Lake Fork (Figure 7-15). The well field collection system consists of various lengths of 18, 24, 30, and 36 inch pipeline totaling over 206,000 feet. The transmission line to the Lake Fork pump station is almost 98,000 feet of 78-inch pipe. The Lake Fork and Tawakoni transmission pipelines will be used to convey supplies from this strategy to DWU's Eastside WTP.

Figure 7-15. Sabine Conjunctive Use Parts 1 – Carrizo-Wilcox Groundwater



7.6.1.2 WATER AVAILABILITY

Available groundwater in the Carrizo-Wilcox and Queen City aquifers was estimated in Smith, Upshur and Wood counties after comparing current and future estimated groundwater demands with the modeled available groundwater (MAG) amounts for each county as estimated by the TWDB. Table 7-24 summarizes groundwater availability for each aquifer by county and shows that up to 90 MGD (101,358 acft/yr) of groundwater is potentially available. Percentages by county and aquifer are also shown in parentheses. The TWDB MAG volumes were updated in 2021, therefore the volumes reported in Table 7-24 are different compared to the volumes in the 2014 plan. The previous groundwater availability reported for the three counties in the 2014 plan was 102,930 acft/yr (92 MGD).

Table 7-24. Available Groundwater Quantities

County	Queen City (acft/yr)	Carrizo-Wilcox (acft/yr)	Total Available (acft/yr)	Queen City (MGD)	Carrizo-Wilcox (MGD)	Total Available (MGD)
Smith	32,578	25,546	58,124 (57%)	29.06	22.79	51.85 (57%)
Upshur	12,165	6,657	18,822 (19%)	10.85	5.94	16.79 (19%)
Wood	6,510	17,902	24,412 (24%)	5.81	15.97	21.78 (24%)
Totals	**51,253 (51%)**	**50,105 (49%)**	**101,358**	**45.72 (51%)**	**44.70 (49%)**	**90.42**

A Groundwater Availability Model (GAM) was used to calculate aquifer response to the proposed Groundwater project. The GAM was initially used to simulate future groundwater pumping by local entities without DWU's demand. This simulation was used to establish a baseline to compare against a second scenario that included both local and DWU pumping. Based on a comparison of these modeling scenarios, it was determined that up to 27 MGD (30,000 acft/yr) could be developed by DWU in these three counties with groundwater level declines of not much more than 100 feet. This level of development represents about 29% of the total available groundwater for these aquifers in these three counties. Table 7-25 includes a summary of production from the three aquifers by county for the 27 MGD (30,000 acft/yr) Groundwater project. The Queen City aquifer will provide 60 percent of the total production and remaining 40 percent would be pumped from the Carrizo-Wilcox Aquifer.

Table 7-25. Proposed Production Quantities by Unit

Aquifer	Smith (acft/yr)	Wood (acft/yr)	Upshur (acft/yr)	Total (acft/yr)	Smith (MGD)	Wood (MGD)	Upshur (MGD)	Total (MGD)
Queen City	6,000	6,000	6,000	18,000	5.35	5.35	5.35	16.05
Carrizo	0	6,000	0	6,000	0.00	5.35	0.00	5.35
Wilcox	0	6,000	0	6,000	0.00	5.35	0.00	5.35
TOTAL	**6,000**	**18,000**	**6,000**	**30,000**	**5.35**	**16.05**	**5.35**	**26.75**

7.6.1.3 PROJECT COSTS

The 2024 LRWSP has not included a cost of leasing groundwater, which would need to be negotiated by DWU for the project to be implemented. The groundwater component of the project requires several well fields as shown in Figure 7-15. These well fields include 90 Queen City wells, 10 Carrizo wells and 10 Wilcox wells. Delivery of water from the well fields to the Lake Fork pump station requires 58-miles of pipeline ranging in diameter between 18 and 78 inches. Two pump stations are located along the collections system lines to deliver Wood County groundwater with additional booster stations required to deliver groundwater to the Lake Fork Pump Station. These facilities have been sized to carry the full capacity of the conjunctive use project, though the full capacity will not be utilized until the OCR is constructed in the second phase of implementation.

A summary of total project and annual costs for this strategy with delivery to the Eastside WTP is listed in Table 7-26. Total project costs are $695 million with energy costs for delivery of supplies through DWU's East Side Transmission system estimated at $85,000 per MGD. Annual costs for the project total $59 million based on a 20-year debt service with a 3.5 percent interest rate. The unit cost of water for this project would be approximately $1,971 per acft or $6.05 per 1,000 gallons. After debt service, the unit cost of water is decreased to $342 per acft or $1.05 per 1,000 gallons.

Table 7-26. Sabine Conjunctive Use Part 1 – Groundwater Costs

Item	Estimated Costs for Facilities
Intake Pump Stations (8.5 MGD)	$12,030,000
Transmission Pipeline (18-78 in. dia., 57.7 miles)	$263,637,000
Transmission Pump Station(s) & Storage Tank(s)	$58,396,000
Well Fields (Wells, Pumps, and Piping)	$150,872,000
TOTAL COST OF FACILITIES	**$484,935,000**
- Planning (3%)	$14,133,000
- Design (7%)	$32,978,000
- Construction Engineering (1%)	$4,711,000
Legal Assistance (2%)	$9,422,000
Fiscal Services (2%)	$9,422,000
Pipeline Contingency (15%)	$37,472,000
All Other Facilities Contingency (20%)	$44,260,000
Environmental & Archaeology Studies and Mitigation	$8,484,000
Land Acquisition and Surveying (1010 acres)	$6,654,000
Interest During Construction (3.5% for 2 years with a 0.5% ROI)	$42,411,000
TOTAL COST OF PROJECT	**$694,882,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$48,893,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$4,129,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,454,000
Pumping Energy Costs (26618908 kW-hr @ 0.09 $/kW-hr)	$2,396,000
Delivery through Eastside Supply Pipeline ($85,000 //MGD)	$2,269,000
TOTAL ANNUAL COST	**$59,141,000**
Available Project Yield (acft/yr)	30,000
Annual Cost of Water ($ per acft), based on PF=0	$1,971
Annual Cost of Water After Debt Service ($ per acft), based on PF=0	$342
Annual Cost of Water ($ per 1,000 gallons), based on PF=0	$6.05
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=0	$1.05

7.6.1.4 WATER QUALITY

The water quality in both aquifers in all three counties is good with no known impairments. TDS in both aquifers is below the drinking water standard of 1,000 mg/L on average in the proposed wellfield. Water quality in the Queen City wells may have high Iron (160 – 2,100 ug/l) and Manganese (12 – 19 mg/l) concentrations but considering that this water will be blended with other supplies, this is not a significant concern.

7.6.1.5 ENVIRONMENTAL IMPACTS

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[17] and IPaC[18]; TPWD, TXNDD[19] and species county lists[20]; and the USGS NHD[21]. Table 7-27 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of these desktop environmental factors; further desktop and field studies would be included in any feasibility or permitting efforts to address these potential concerns with the respective regulatory agencies.

7.6.1.5.1 HABITAT

The well fields and transmission infrastructure would be located to avoid conflicts with environmentally sensitive areas when feasible. Although, not finalized, the proposed transmission pipeline route would cross sections of the Old Sabine Bottom Wildlife Management Area and Little Sandy National Wildlife Refuge, one Texas Parks and Wildlife Department designated ecologically significant stream segment, and areas of bottomland hardwoods. The majority of the pipeline route occurs within post oak and pine forested areas, but it also crosses areas of agricultural use including crops and pasture. Impacts to preferred habitats will be minimized by utilizing the agricultural areas which have been previously disturbed as is practicable. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that would be crossed by the pipeline corridor. These wooded areas are utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross NWI-identified wetland areas that might be disturbed by construction activities.

The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities would help to minimize potential impacts to the discussed sensitive natural areas. Collector pipelines, pump stations and well areas generally do not present a substantial impact to existing habitat due to the small areas of temporary or permanent disturbance. Specific project components such as pipelines and wells generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing habitat are anticipated to be low to medium.

---

[17] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[18] US Fish and Wildlife Service. (2024). *Information for Planning and Consulting (IPAC)*. Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[19] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[20] Texas Parks and Wildlife Department. (2024). *Rare, Threatened, and Endangered Species of Texas (RTEST)*. Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[21] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

7.6.1.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Sabine Conjunctive Use Part 1 - Groundwater project is assumed to have medium potential impact to the amount of instream flows since developing up to 30,000 acft/yr of water from the aquifers could result in a decline in groundwater of about 100 feet.

7.6.1.5.3 BAYS AND ESTUARIES

Similarly, the Sabine Conjunctive Use Part 1 project could have low impact on freshwater inflow to the Sabine Lake and Sabine Lake Estuary.

7.6.1.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-27 represent all species federally or state listed as threatened or endangered and federal candidate and proposed species in the counties for which the project will be located. The project area includes 18 species that meet these criteria (county species list and IPaC). These species would need to be considered through the design process and could potentially require mitigation measures during project permitting and implementation. There is proposed critical habitat for the Louisiana pigtoe and the Texas heelsplitter within the project area. Siting of the pipelines and wells to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.6.1.5.5 WETLANDS

Although several NWI-mapped wetlands occur along the proposed pipeline corridors and well field areas, flexibility in the pipeline and well siting could be used to minimize or avoid potential impacts to many of these areas.

7.6.1.5.6 AGRICULTURAL AND NATURAL RESOURCES

Construction activities associated with the project transmission pipeline would impact an estimated 85 acres of soils identified by the USDA as prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because these areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above.

Table 7-27. Environmental Factors for Sabine Conjunctive Use Parts 1 & 2

Environmental Factors	Comment(s)
Habitat	Environmentally sensitive areas were identified during the desktop review. The alignment crosses observations of the proposed threatened alligator snapping turtle and Louisiana pine snake. Part of the pipeline passes through a Water Oak-Willow Oak series community. Low to Medium Impact
Environmental Water Needs	Low Impact
Bays and Estuaries	Low Impact
Threatened and Endangered Species	Tricolored bat (PE), piping plover (ST, FT), rufa red knot (ST), alligator snapping turtle (PT), Louisiana pigtoe (PT,ST), Texas heelsplitter (PE), monarch butterfly (C), southern hickorynut (ST), Louisiana pine snake (ST), northern scarlet snake (ST), Texas horned lizard (ST), black bear (ST), Bachman's sparrow (ST), black rail (ST), wood stork (ST), white-faced ibis (ST), sandbank pocketbook (ST), western creek chubsucker (ST) The Project area contains proposed critical habitat for the Louisiana Pigtoe and the Texas Heelsplitter. Medium Impact
Wetlands	Medium Impact

Source: USFWS, 2024 and TPWD 2024.

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened.
C = Candidate for Federal Listing.

7.6.1.6 CONFIDENCE AND PERMITTING

Currently, there are no local groundwater conservation districts in the three counties and consequently no pumping permits would be required. To pump the groundwater, DWU would need to either purchase the land for the wells or enter into lease agreements with landowners to construct wells and access the groundwater. It is likely that Groundwater Conservation Districts would form if DWU began to pursue a groundwater pumping strategy of this magnitude. A Section 404 permit from the USACE for impacts to a waters of the U.S. from construction activities would likely be needed for the construction of the transmission facilities.

7.6.1.7 FLEXIBILITY AND PHASING

The biggest challenge to groundwater development is the relatively low well yields of the Queen City aquifer where groundwater is available. The low well yields require a large number of wells to be drilled and maintained to recover a relatively small amount of groundwater. Further, required spacing of the large number of wells to minimize long-term interference between wells creates the need for long conveyance pipelines.

The reliability of this strategy is something to be factored into consideration. Groundwater is a very stable supply source and may offer some drought resistant properties to the DWU system. Note that the strategy described herein was one of several groundwater strategies studied in the 2014 Dallas LRWSP. Another configuration of this same strategy was to deliver the water through Lake Palestine and into Dallas' system using the IPL and other available infrastructure. The availability of such an option improves the flexibility of the strategy.

The most important flexibility and phasing consideration to make is the fact that the OCR in Part 2 can be brought on after the construction of the well field, making it a phased project.

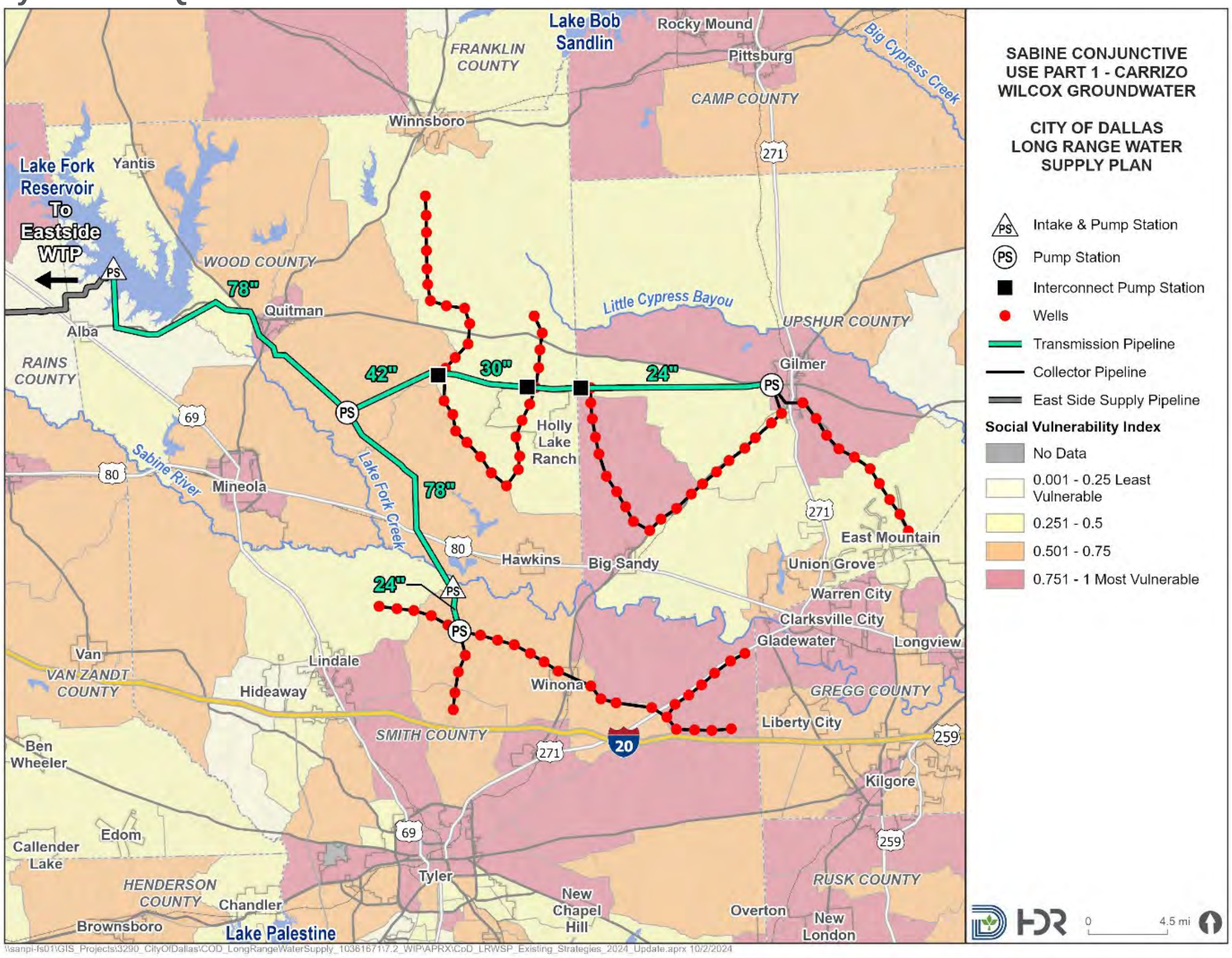
7.6.1.8 EQUITY IMPACTS

Impacts to equity from implementation of Part 1 of the Sabine Conjunctive Use strategy may result from placement of potential project infrastructure such as the wellfield, pump stations, and transmission pipelines. Equity was evaluated by examining the percent area of project components located within each quartile of the CDC's Social Vulnerability Index (see Table 7-28 and Figure 7-16). The project infrastructure is located in all quartiles of the CDC's SVI. The transmission pipeline mainly goes through the 2nd and 3rd quartiles. The wellfields are in the 2nd, 3rd, and 4th quartiles. Fifty-two percent of the project is located in the 3rd and 4th quartiles of the CDC's SVI, meaning that half of the infrastructure for this project is located in areas likely to experience significant equity impacts.

Table 7-28. Sabine Conjunctive Use Part 1 SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	**2nd quartile**	**3rd quartile**	**4th quartile (high) highly vulnerable**	**Value**
4.5%	43.8%	32.4%	19.2%	**3**

Figure 7-16. Sabine Conjunctive Use Part 1- Carrizo Wilcox Groundwater Equity Impact by CDC SVI Quartile



7.6.2 Part 2 – Sabine River Off-Channel Reservoir

The 2024 plan differs from the 2014 plan in that it proposes the Sabine Conjunctive Use Project in phases. The Sabine River Off-Channel Reservoir (OCR) is the second phase of the Sabine Conjunctive Use strategy and is what allows the project to operate as a conjunctive-use resource utilizing groundwater to supplement the yield of an off-channel reservoir during times of low river flows. The OCR was referred to as the "Smith 1B Off Channel Reservoir" in the 2014 LRWSP.

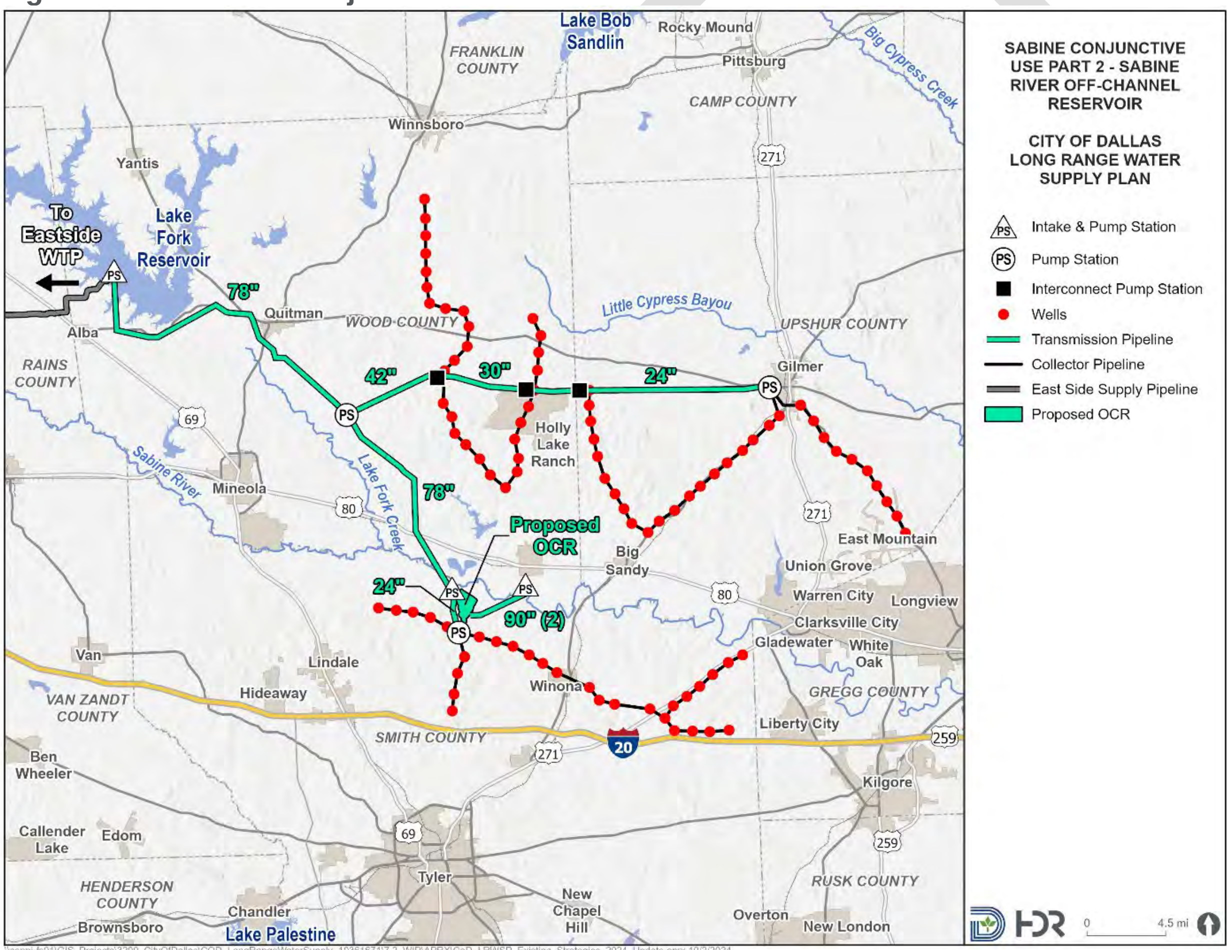
7.6.2.1 STRATEGY DESCRIPTION

The two projects selected for the combined operations are the Sabine River off-channel reservoir (OCR) with a storage capacity of 67,200 acft and the Carrizo-Wilcox Groundwater project. The Carrizo-Wilcox Groundwater project is discussed in detail in Section 7.6.1.1. The OCR project was evaluated as part of the development of the 2014 Dallas LRWSP, but the stand-alone project did not score high enough to be a recommended or alternative strategy. The following is a description of that strategy.

The OCR stores streamflow diverted from the Sabine River using a 400 cfs (258 MGD) intake and pump station and two 90-inch diameter short-distance transmission pipelines. Water stored in the OCR is subsequently diverted at a maximum rate of 93 MGD to the Lake Fork pump station through a 78-inch diameter pipeline. The stand-alone evaluation of this strategy showed that this site has a surface area of 799 acres and could store 78,036 acft of water producing a firm yield of 67,200 acft/yr (60.0 MGD) by relying on available stream flows from the Sabine River for diversion into the reservoir. Figure 7-17 shows the locations of the OCR, well fields, transmission pipelines, and pipeline diameters, and pump stations for this strategy.

The OCR site was chosen because of its close proximity to the groundwater well fields and provided the largest amount of supply of the OCRs evaluated in this area. Supplies from the OCR and well fields are both delivered to the Lake Fork pump station as shown in Figure 7-17 for subsequent delivery to DWU's Eastside WTP via the Eastside pipeline.

Figure 7-17. Sabine Conjunctive Use Part 2 –Sabine River Off-Channel Reservoir



7.6.2.2 WATER AVAILABILITY

The Sabine conjunctive use project is operated with the primary source being surface water from the OCR. During wet periods the OCR is over-drafted when available stream flow is abundant. The groundwater supplies are used to backup the surface water supplies when surface water becomes limited. This operating plan uses groundwater to help meet demands during drought periods and minimizes the use of the groundwater when surface water is plentiful. The OCR was the component selected to be over-drafted, or drained at a faster rate than it can be replenished, because of its ability to quickly refill as compared to the longer recharge times of groundwater aquifers.

A daily time-step spreadsheet model was created to optimize the operations of the two components in order to deliver the maximum amount of supplies without shortages for the 1940 to 1998 simulation period (period of record available in the Sabine WAM). Scenarios were simulated with varying OCR storage trigger levels to signal when groundwater pumping would commence. A groundwater analysis was performed and determined the maximum pumping capacity from the well fields was 40 MGD (44,500 acft/yr). By assuming this maximum pumping capacity in the conjunctive use model, an optimal OCR trigger level was selected to begin groundwater pumping. This level was determined to be 80 percent of conservation storage.

The conjunctive use system is able to provide a firm yield of 93 MGD (104,200 acft/yr). This was the maximum yield achievable without wells going dry (dry cells in the groundwater simulation model) or the OCR reduced to zero storage. If the OCR component and groundwater component are not operated as a system, they have a combined yield of 87 MGD (97,200 acft/yr) with 60 MGD from the OCR and 27 MGD from groundwater. By operating the two strategies as a system, the combined yield is increased by about 6 MGD (7,000 acft/yr) or about 7 percent.

Figure 7-18 shows the storage trace of the OCR for the demands and trigger levels previously described as applied during the 1940 to 1998 simulation period. During the critical drought of the 1950s, storage levels are nearly reduced to zero. However, the OCR storage levels remain over half full 94 percent of the time. This demonstrates the reliability of the surface water supply and the selection of the OCR as the optimal component of the system to overdraft.

Figure 7-19 shows the annual supply amounts from both surface water and groundwater for the simulation period. The figure shows that groundwater is relied upon the most during the 1950s drought. Figure 7-20 shows a frequency of annual supply from the OCR and groundwater. The maximum annual groundwater supply of 40 MGD is needed in only 3 years of the simulation or about 5 percent of the time. On average, only 14 MGD or 15,666 acft/yr of supplies come from groundwater (or about 52 percent of the 30,000 acft/yr required for the stand-alone Groundwater project from the 2014 LRWSP. In 10 years of the simulation or about 17 percent of the time, the entire supply comes from surface water.

Figure 7-18. Off-Channel Reservoir Conservation Storage Trace for 1940 to 1998 Simulation Period

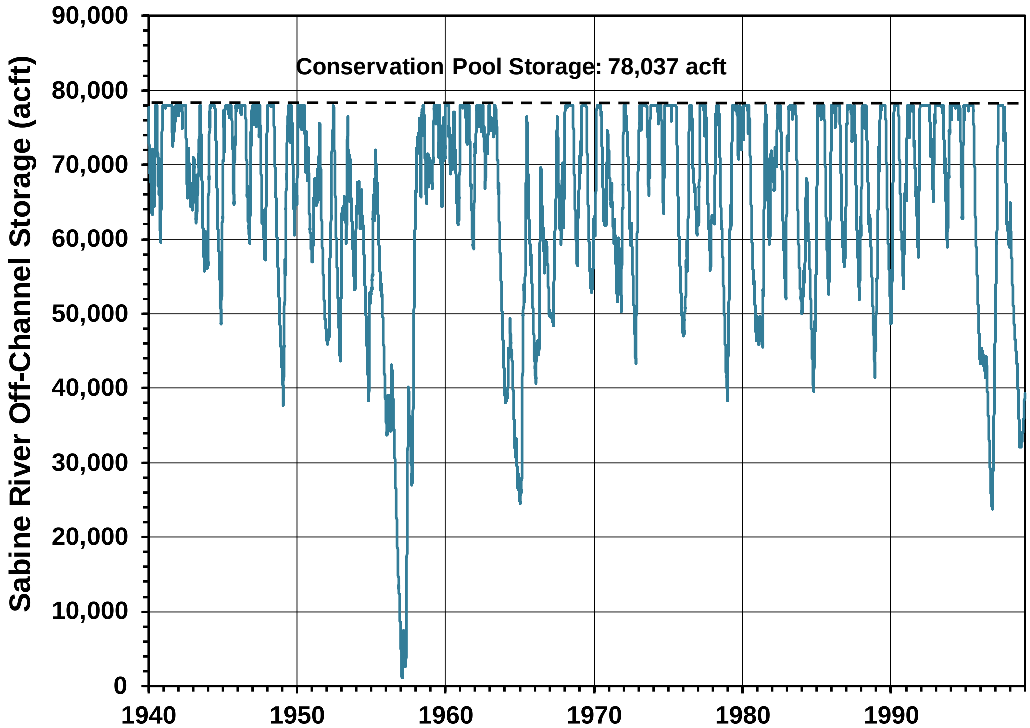


Figure 7-19. Sabine Conjunctive Use Supply Sources (1940 to 1998)

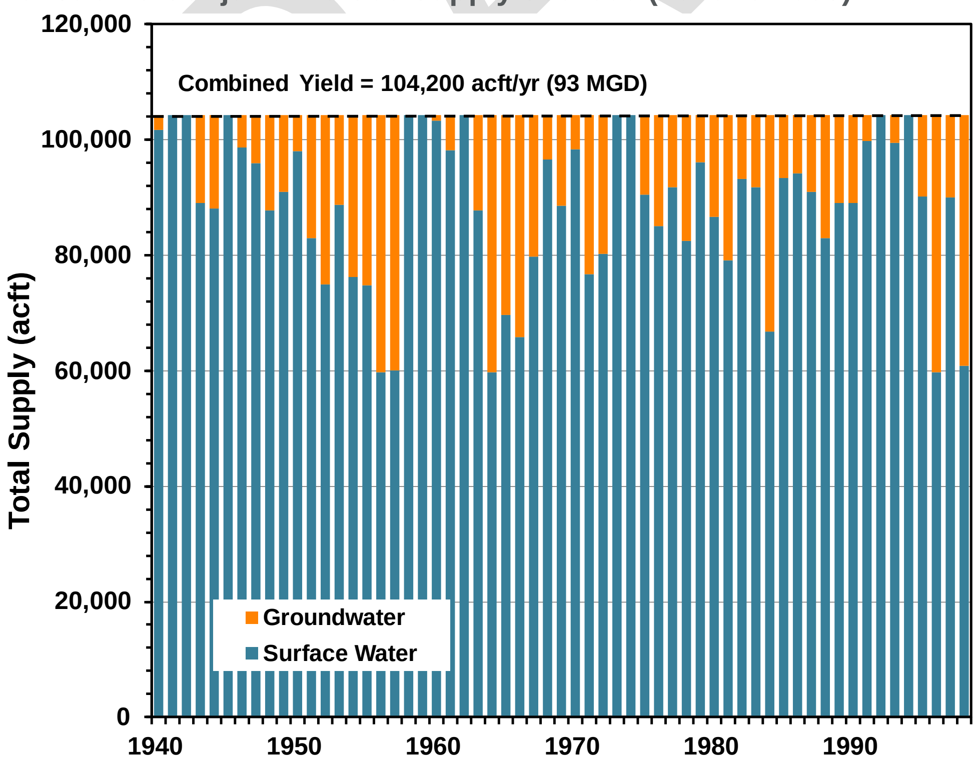
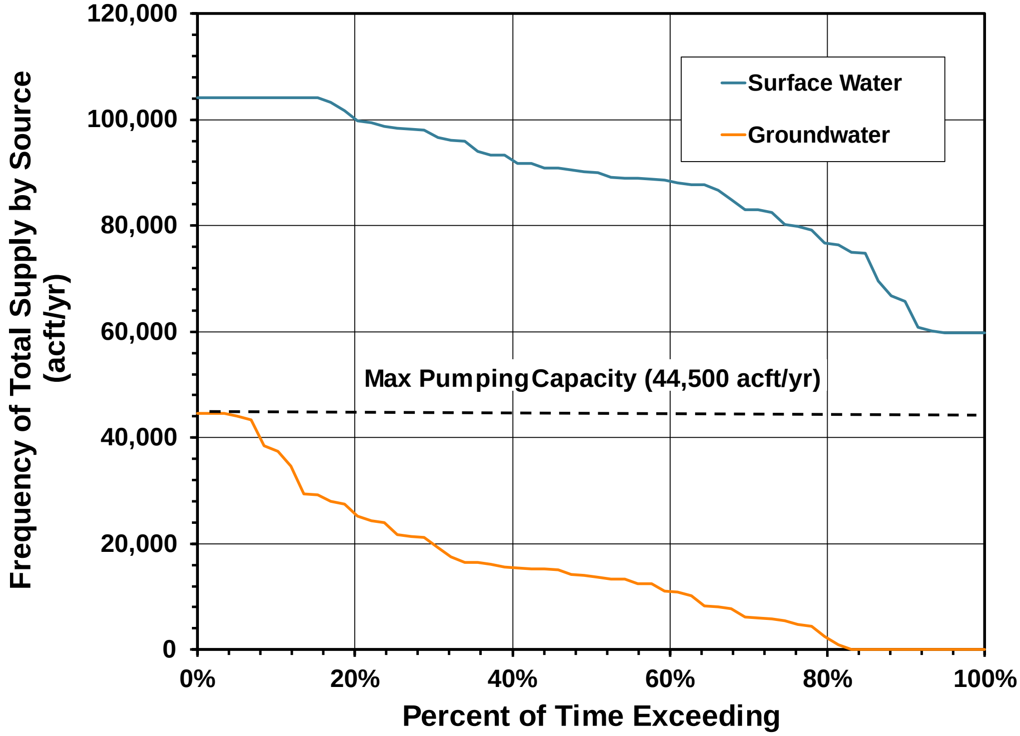


Figure 7-20. Frequency of Use Supply Sources (1940 to 1998)



7.6.2.3 PROJECT COSTS

Project costs for the Sabine River OCR and connection to the transmission facilities from Part 2 are summarized in Table 7-29. The 2024 LRWSP has not included an estimate for the cost of purchasing surface water right on the Sabine River; this will need to be negotiated by DWU before the project can be implemented. The addition of the OCR will increase the project yield by 66 MGD (74,200 acft/y) and cost roughly $903 million dollars in September 2023 dollars. This would make the combined project yield 93 MGD (104,200 acft/yr) and cost $1.598 billion. The annual cost of the OCR and related infrastructure and its operation is roughly $75 million bringing the total project cost to approximately $134 million annually. The unit cost of bringing Part 2 of the Sabine Conjunctive Use project online is $1,004 per acft or $3.08 per 1,000 gallons. The overall unit cost of water for the combined project is $1283 per acft or $3.94 per thousand gallons.

The benefit of the projects being operated as one system is the ability to share the transmission pipeline from the well field and the OCR to the Lake Fork pump station. While the pipeline and pump stations for the conjunctive system are larger than the stand-alone projects, there are some costs savings associated with the shared facilities.

Table 7-29. Sabine Conjunctive Use Part 2 - OCR Costs

Item	Estimated Costs for Facilities
Dam and Reservoir (Conservation Pool acft, acres)	$13,201,000
Off-Channel Storage/Ring Dike (Conservation Pool acft, acres)	$401,621,000
Intake Pump Stations (63.1 MGD)	$130,022,000
Transmission Pipeline (24-90 in. dia., 7.5 miles)	$77,546,000
TOTAL COST OF FACILITIES	**$622,390,000**
- Planning (3%)	$18,672,000
- Design (7%)	$43,567,000
- Construction Engineering (1%)	$6,224,000
Legal Assistance (2%)	$12,448,000
Fiscal Services (2%)	$12,448,000
Pipeline Contingency (15%)	$11,597,000
All Other Facilities Contingency (20%)	$109,015,000
Environmental & Archaeology Studies and Mitigation	$6,801,000
Land Acquisition and Surveying (380 acres)	$5,002,000
Interest During Construction (3.5% for 2 years with a 0.5% ROI)	$55,132,000
TOTAL COST OF PROJECT	**$903,296,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$22,211,000
Reservoir Debt Service (3.5 percent, 40 years)	$27,517,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$775,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$3,251,000
Dam and Reservoir (1.5% of Cost of Facilities)	$6,222,000
Pumping Energy Costs (99254469 kW-hr @ 0.09 $/kW-hr)	$8,933,000
Delivery through Eastside Supply Pipeline ($ 85,000/ MGD)	$5,612,107
TOTAL ANNUAL COST	**$74,521,107**
Available Project Yield (acft/yr)	74,200
Annual Cost of Water ($ per acft), based on PF=0	$1,004
Annual Cost of Water After Debt Service ($ per acft), based on PF=0	$334
Annual Cost of Water ($ per 1,000 gallons), based on PF=0	$3.08
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=0	$1.03

7.6.2.4 WATER QUALITY

The Sabine River at the project location is listed as free of impairments by the TCEQ and EPA. The water quality in both aquifers in all three counties is good with no known impairments. TDS in both aquifers is below the drinking water standard of 1,000 mg/L on average in the proposed wellfield. Water quality in the Queen City wells may have high

Iron (160 – 2,100 ug/l) and Manganese (12 – 19 mg/l) concentrations but considering that this water will be blended with other supplies, this is not a significant concern.

7.6.2.5 ENVIRONMENTAL IMPACTS

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[22] and IPaC[23]; TPWD, TXNDD[24] and species county lists[25]; and the USGS NHD[26]. Table 7-27 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of conditions and further study would be needed during feasibility or permitting efforts to address these potential concerns with the respective regulatory agencies.

7.6.2.5.1 HABITAT

The well fields, OCR and transmission infrastructure would be located to avoid conflicts with environmentally sensitive areas when possible. Although, not finalized, the proposed pipeline route will cross sections of the Old Sabine Bottom Wildlife Management Area and Little Sandy National Wildlife Refuge, one TPWD designated ecologically significant stream segment, and areas of bottomland hardwoods. The majority of the pipeline route occurs within post oak and pine forested areas, it also crosses areas of agricultural areas. Impacts to preferred habitats could be minimized by utilizing the agricultural areas which have been previously disturbed. Wooded riparian areas commonly occur along and adjacent to stream and river areas that would be crossed by the pipeline corridor. Wooded areas are utilized by many different species and should be avoided as much as possible. As this is a larger project, the pipeline route also crosses wetland areas, identified on the NWI, which could be disturbed by construction activities. The use of siting to avoid and/or minimize impacts to sensitive habitat areas during design and utilizing BMPs during construction would help to minimize potential impacts to these sensitive natural areas. Collector pipelines, pump stations and well areas do not present a substantial impact to existing habitat due to the small areas of disturbance.

Specific project components such as pipelines and wells generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing sensitive habitat types are anticipated to be low to medium.

---

[22] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[23] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[24] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[25] Texas Parks and Wildlife Department. (2024). *Rare, Threatened, and Endangered Species of Texas (RTEST)*. Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[26] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

7.6.2.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the well fields would not be expected reduce groundwater to a capacity where it would affect stream flows. While Sabine River diversions will periodically reduce Sabine River stream flows during periods of abundant flow, this new diversion will need to be permitted by TCEQ and therefore will comply with applicable TCEQ environmental flow standards.

7.6.2.5.3 BAYS AND ESTUARIES

As a result of the distance, the large intervening drainage area between the diversion site and Sabine Lake and the Sabine Lake Estuary and the diversion pulling only during periods of abundant streamflow, the conjunctive use project would have limited effects on freshwater inflows.

7.6.2.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-27 represent all species federally or state listed as threatened or endangered, and federal candidate species in the counties for which the project will be located. The project area includes 18 species that meet these criteria (IPaC and county species lists). These species would need to be considered and potentially mitigated for during project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail order to determine the feasibility of the project. Additionally, proposed critical habitat for the Louisiana pigtoe (proposed threatened) and the Texas heelsplitter (proposed endangered) occurs within the project area.

7.6.2.5.5 WETLANDS

Although a number of potential wetlands occur along the proposed pipeline corridors and well field areas, based on the NWI, flexibility in the pipeline routing and well siting would be used to minimize or avoid potential impacts to the majority of these areas during design.

Approximately 77 acres of potential wetlands occur within the OCR footprint and would be inundated by the project. A delineation of potential waters of the U.S. would be required during the project development phase to determine impacts. It is likely that coordination with the USACE would be required during the Section 404 permitting process and mitigation would be necessary for these areas.

7.6.2.5.6 AGRICULTURAL AND NATURAL RESOURCES

The OCR would permanently impact an estimated 149 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils. This represents less than 1 percent of the total prime farmland soils found in Smith County. Construction activities associated with the project transmission pipeline would impact an additional 86 acres of prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of state are included in Environmental Impacts section above.

7.6.2.6 CONFIDENCE AND PERMITTING

Implementation of the Sabine River diversion and OCR will require permits from both state and federal agencies as shown in Table 7-30. A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the OCR and transmission facilities.

Table 7-30. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit	TCEQ	Will require an inter-basin transfer authorization to transfer water to the Trinity River Basin.
Section 404	USACE	Required for construction activities in waters of the US.

7.6.2.7 FLEXIBILITY AND PHASING

The OCR component of the project is susceptible to performance risk associated with a worse drought of record and future upstream impoundments. The biggest challenge to groundwater development is the relatively low well yields of the Queen City aquifer where groundwater is available. The low well yields require a large number of wells to be drilled and maintained to recover a relatively small amount of groundwater. Further, required spacing of the large number of wells to minimize long-term interference creates the need for long conveyance pipelines. Without a groundwater conservation district, the rule of capture applies and there is not a regulatory framework to protect financial investment of a well producer. However, it is likely that if Dallas were to move forward with the Groundwater project, that a district would be created that could potentially limit the amount of groundwater that an entity like Dallas would be allowed to develop.

The ability to phase this project and operate as a whole will provide greater ability to manage both sources in conjunction with the other. The greater reliance on the OCR will provide relief to the groundwater source which will be beneficial to the management of the aquifer system. This will be a positive for Dallas if and when a groundwater district is created to manage overall production from the aquifer system.

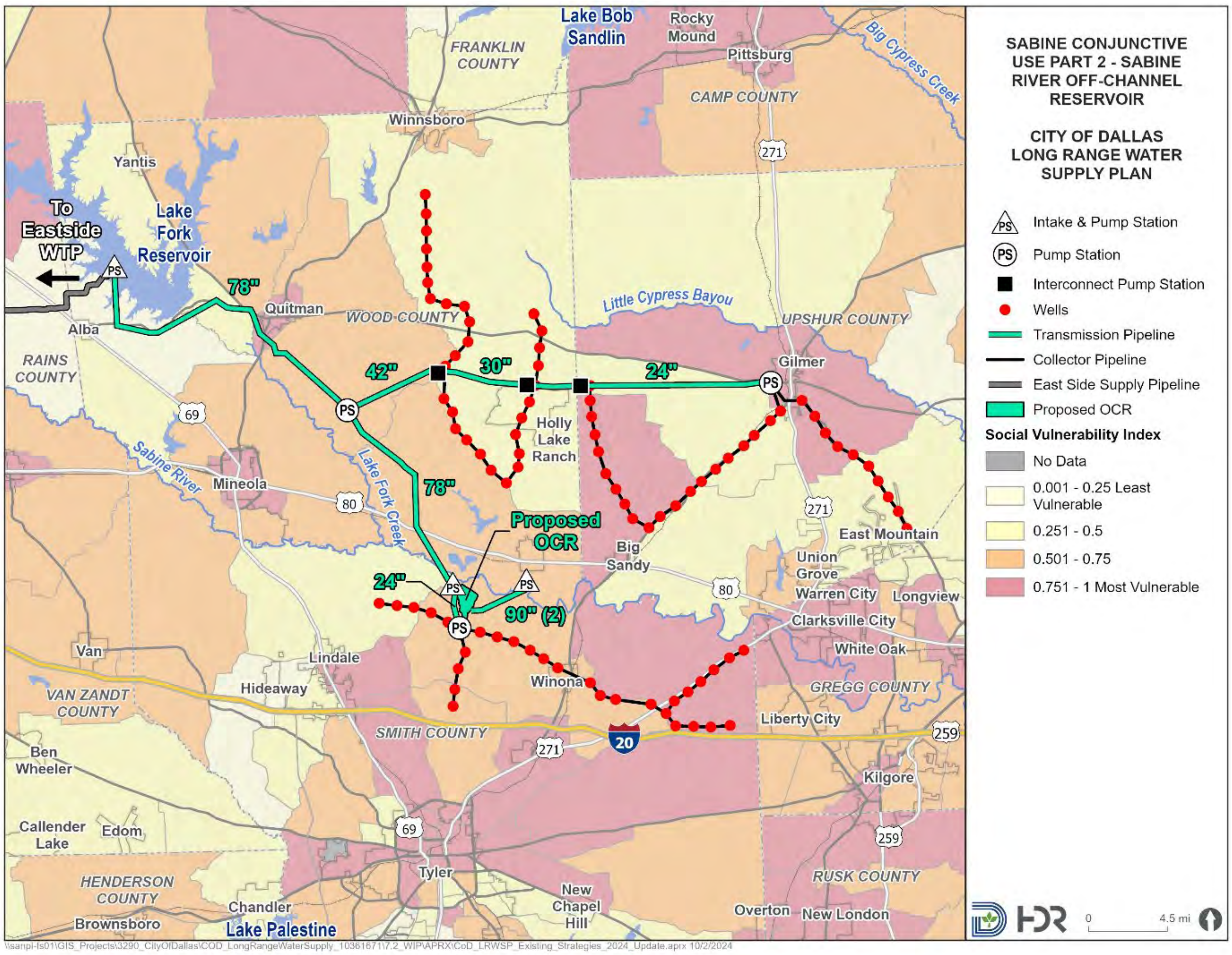
7.6.2.8 EQUITY IMPACTS

Impacts to equity from implementation of the Sabine Conjunctive Use strategy may result from placement of potential project infrastructure such as the off-channel reservoir, transmission pipelines, and well fields. Equity was evaluated by examining the percent area of project components located within each quartile of the CDC's Social Vulnerability Index. (see Table 7-23 and Figure 7-21). The project infrastructure is located in all quartiles of the CDC's SVI; the off-channel reservoir is located in the 3rd quartile, the pump station is in the 3rd quartile, and the transmission pipeline goes through all quartiles). Seventy-four percent of the project is located in the 3rd or 4th quartile of the CDC's SVI, meaning that much of the infrastructure for this project is located in areas likely to experience significant equity impacts.

Table 7-31 Sabine Conjunctive Use Parts 1 and 2 SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
2.4%	23.4%	63.9%	10.3%	2

Figure 7-21. Sabine Conjunctive Use Parts 1 and 2 Equity Impact by CDC SVI Quartile



7.7 Neches River Basin Supply

There are two proposed recommended strategies located in the Neches River Basin – Neches Run-of-River and Lake Columbia. Both projects assume delivery to the DWU system through the available capacity in the IPL. Dallas' capacity in the IPL is 150 MGD and, after consideration of Dallas' Lake Palestine supply of 102 MGD, the IPL will initially have available excess capacity of about 48 MGD. Neches Run-of-River and Lake Columbia are both recommended for the 2024 LRWSP, however, since there is only enough capacity in the IPL for one of the Neches River Basin strategies, there will only be implementation of one of these strategies. Additional feasibility studies and analysis should be conducted to determine which strategy would best support Dallas.

7.7.1 Neches Run-of-River

The Neches Run-of-River strategy was a 2014 LRWSP recommended strategy. After reevaluation, this strategy has again been designated as a recommended strategy in the 2024 LRWSP.

In 2013 Dallas and the Upper Neches River Municipal Water Authority (UNRMWA) initiated the Upper Neches River Water Supply Project Feasibility Study[27] (study) to evaluate options to replace the Fastrill Reservoir project that was rendered not feasible by the establishment of a US Fish & Wildlife Service (USFWS) wildlife refuge in the footprint of the reservoir. The study provided technical evaluations of a range of potential water supply strategies for an Upper Neches Project. These strategies include run-of-river diversion of unappropriated water from the upper Neches River operated conjunctively with tributary storage, groundwater, and/or system operations with Lake Palestine. Dallas and UNRMWA are long-term partners on Lake Palestine with the initial water sale contract being in place since 1972.

After considering the various strategy scenarios developed during the course of the study, Dallas decided the preferred Upper Neches Project would include run-of-river diversion of unappropriated streamflow from the Neches River operated conjunctively with Lake Palestine. This additional water supply would be used to supplement existing water supplies available to Dallas from Lake Palestine and potentially other UNRMWA customers.

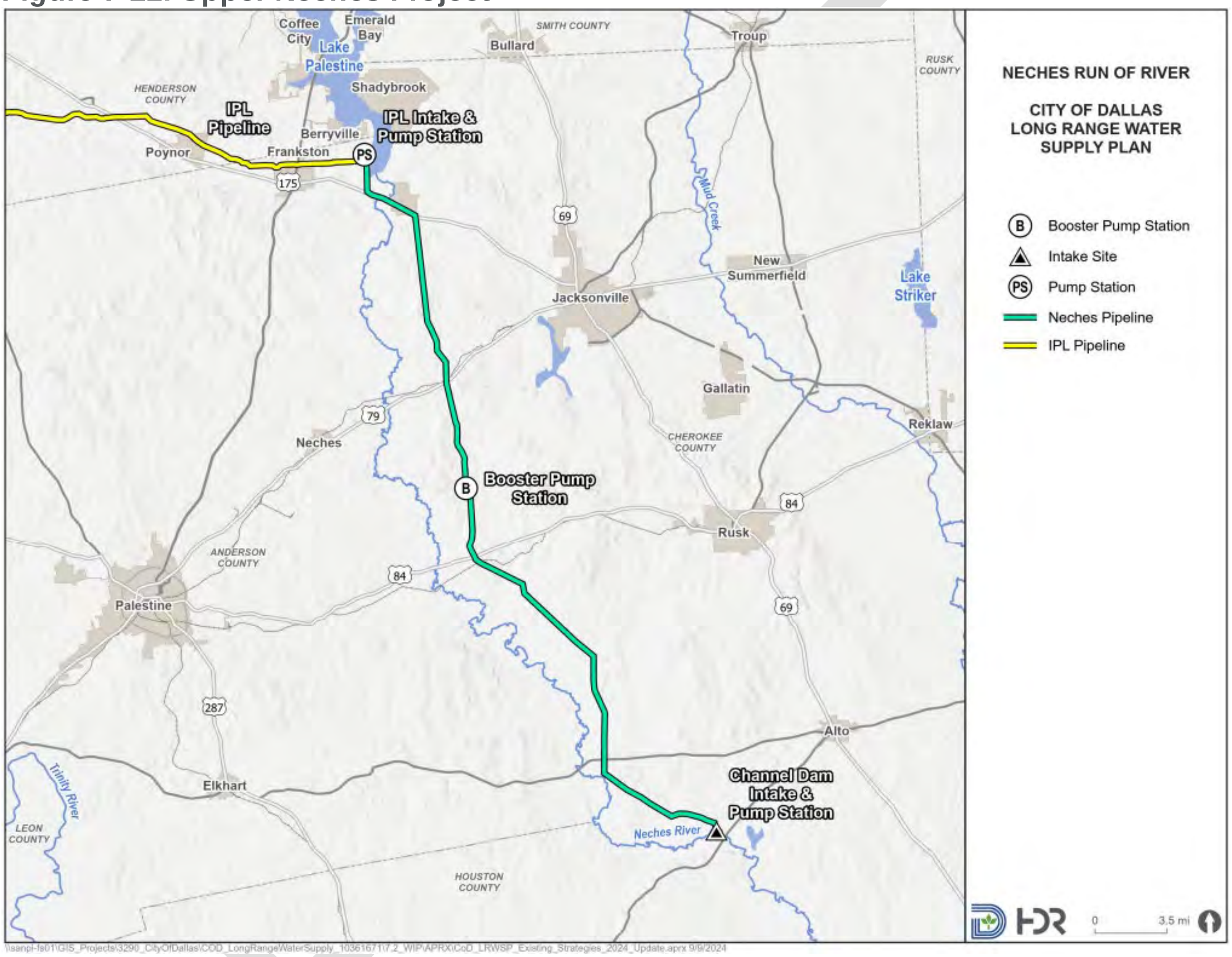
The proposed integrated pipeline project (IPL) includes the construction of a new intake and pump station at Lake Palestine that is currently proposed to have an initial 150 MGD capacity to deliver Dallas' Lake Palestine supplies through the IPL. Dallas' existing contract with UNRMWA for Lake Palestine water is for 53.73% of the annual dependable yield, limited to 114,337 acft/yr (102 MGD). For the 2024 LRWSP, it was assumed that Dallas would contract for the additional supply unused by local water users for a total supply of 102 MGD from Lake Palestine. (See section 5.5.1 for additional information regarding the Lake Palestine supply assumptions). Since the IPL will have a capacity of 150 MGD, the remaining capacity of approximately 48 MGD (or about 53,800 acft/yr) could be utilized by Dallas to deliver additional water from the Neches Run-Of-River strategy.

[27] UNRMWA. Upper Neches River Water Supply Project Feasibility Study. HDR 2014.

7.7.1.1 STRATEGY DESCRIPTION

The selected Neches Run-of-River strategy includes a new river intake and pump station for a run-of-river diversion from the Neches River near the SH 21 crossing. Water would be delivered through a 42-mile pipeline (23 miles of 72-inch diameter pipe and 19 miles of 66-inch pipe) to Dallas' pump station at Lake Palestine for delivery to Dallas through the IPL. Facilities include a small diversion dam on the Neches River, a river intake and pump station, and a transmission pipeline and booster pump station with delivery to the IPL pump station site near Lake Palestine (Figure 7-22).

Figure 7-22. Upper Neches Project

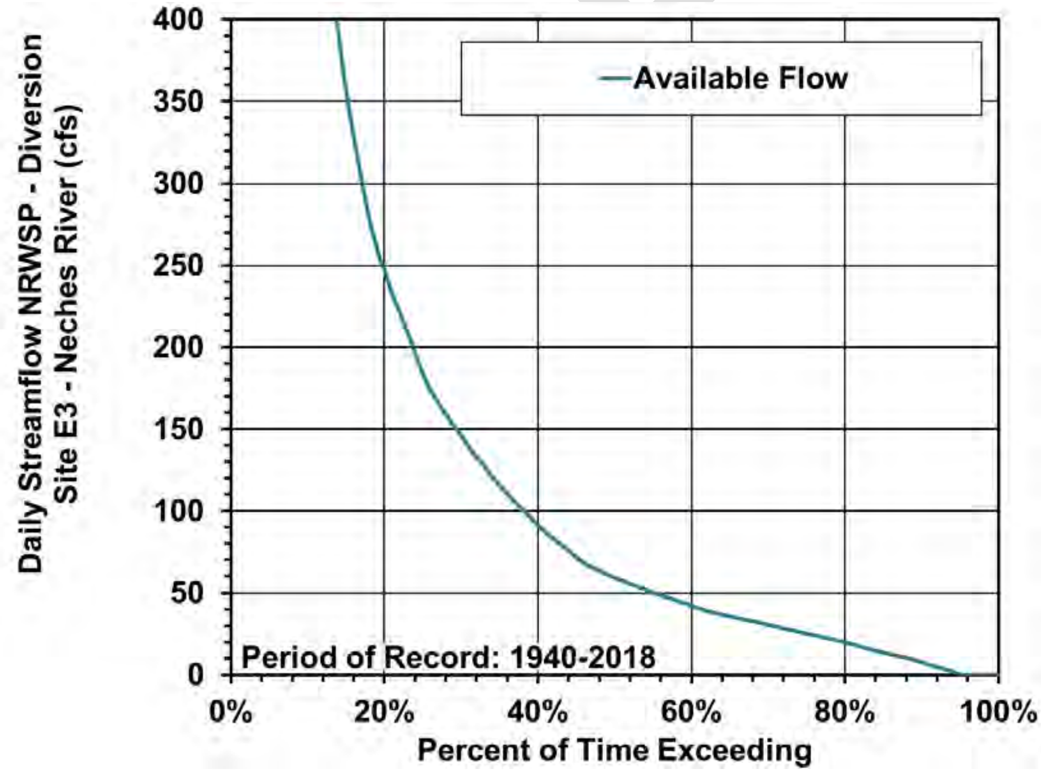


7.7.1.2 WATER AVAILABILITY

The Neches Run-of-River strategy includes a run-of-river diversion from Neches River backed up by storage in Lake Palestine when streamflows are not available due to drought conditions, senior water rights calls, and/or TCEQ environmental flow restrictions. Water availability at this diversion point was computed based on a maximum diversion rate of 141 cfs (91 MGD). The firm yield for this strategy is about 74 MGD (82,900 acft/yr), assuming conjunctive system operations with Lake Palestine. This firm yield was calculated using the 2021 version of TCEQ's Neches River Basin Water Availability Model (Neches WAM) which covers the 1940 to 2018 timeframe.

Figure 7-23 illustrates the percent of time that unappropriated water is available for diversion from the Neches River near SH 21 under a new appropriation. The transmission capacity of a 72-inch pipeline (~141 cfs or 91 MGD) is available about 31 percent of the time. Since the new run-of-river diversions will be interruptible, the firm yield associated with the Upper Neches Project is the incremental increase in the firm yield of Lake Palestine resulting from system operations of the new diversion and the existing reservoir. The resulting incremental system firm yield is 74 MGD (82,900 acft/yr). In 2010, the UNRMWA reached a settlement agreement[28] with the Lower Neches Valley Authority regarding water right subordination in the Neches River Basin. This agreement was incorporated into the water availability analysis of this strategy. Despite the incremental system firm yield being higher, the water available for this strategy is limited by the available capacity in the IPL, which is 48 MGD (53,800 acft/yr).

Figure 7-23. Streamflow Available for Diversion near SH 21



7.7.1.3 PROJECT COST ESTIMATE

The Neches Run-of-River strategy requires a channel dam and river intake facilities on the Neches River and a transmission pipeline with a booster pump station to deliver the supplies to the Lake Palestine IPL pump station. The channel dam will create a suitable

[28] UNRMWA settlement agreement with LNVA effective June 23, 2010 reference SOAH Docket No. 582-10-0159; TCEQ Docket No. 2009-0168-WR Lower Neches Valley Authority's Application for Amendment to Certificate of Adjudication No. 06-4411. Attached as Appendix N.

pool depth near the intake and pump station to ensure submergence of the intake for reliable operations. Most of the length of this channel dam will function as an overflow spillway for passing inflows. The main channel of the Neches River near the intake location ranges between 85 and 200 feet wide.

The 141 cfs (91 MGD) intake and pump station will be located on the east side of the Neches River near SH 21. A 42 mile transmission pipeline (23 miles of 72 inch diameter pipe and 19 miles of 66 inch diameter pipe) will deliver water to the IPL pump station site near Lake Palestine.

A summary of project and annual costs for the Neches run-of-river strategy with delivery to the Joe Pool area through the IPL is listed in Table 7-32. Total project costs are estimated at $719,027,000. Annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and are estimated to be $69,397,000 per year. The unit cost of water for this project to deliver water to the Joe Pool area (via the IPL) would be about $1,290 per acft or $3.96 per 1,000 gallons. After debt service, the unit cost of water is decreased to $192 per acft or $0.59 per 1,000 gallons.

Table 7-32. Cost Estimate Summary for Upper Neches Project

Table units: September 2023 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Channel Dam	$13,201,000
Intake Pump Stations (91.4 MGD)	$69,929,000
Transmission Pipeline (66-72 in. dia., 42.3 miles)	$370,378,000
Transmission Pump Station(s) & Storage Tank(s)	$55,850,000
Integration, Relocations, Backup Generator & Other	$2,283,000
TOTAL COST OF FACILITIES	$511,641,000
OTHER PROJECT COSTS	
Engineering:	
- Planning (3%)	$15,349,000
- Design (7%)	$35,815,000
- Construction Engineering (1%)	$5,116,000
Legal Assistance (2%)	$10,233,000
Fiscal Services (2%)	$10,233,000
Pipeline Contingency (15%)	$55,557,000
All Other Facilities Contingency (20%)	$28,253,000
Environmental & Archaeology Studies and Mitigation	$1,329,000
Land Acquisition and Surveying (266 acres)	$1,756,000
Interest During Construction (3.5% for 2 years with a 0.5% ROI)	$43,745,000
TOTAL COST OF PROJECT	**$719,027,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$50,431,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$3,806,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$2,945,000
Dam and Reservoir (1.5% of Cost of Facilities)	$198,000
Pumping Energy Costs (0.09 $/kW-hr)	$3,371,000
Delivery through IPL ($180,000 per MGD)	$8,646,000
TOTAL ANNUAL COST	**$69,397,000**
Available Project Yield (acft/yr)	53,800
Annual Cost of Water ($ per acft), based on PF=1.9027	$1,290
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.9027	$192
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.9027	$3.96
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.9027	$0.59

7.7.1.4 WATER QUALITY

Based on data from EPA's ATTAINS and the TCEQ 303(d) list, no water quality issues are anticipated with water diverted from the Neches River for this strategy.

7.7.1.5 ENVIRONMENTAL IMPACTS

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[29] and IPaC[30]; TPWD TXNDD[31] and species county list[32]; and the USGS NHD[33].Table 7-33 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project, excluding considerations about the associated IPL pipeline, which can be found in the Chapter 7 discussion of the IPL Connection to the DWU System. These categories provide a general summary of these desktop environmental conditions and further study would be needed in any feasibility or permitting effort to address these potential concerns with the respective regulatory agencies.

7.7.1.5.1 HABITAT

The vegetation near the river ranges from bald-cypress dominated swamps to mixed pine-hardwood stands depending on local river flooding and floodplain topography. River and transmission infrastructure would be located to avoid conflicts with the Neches River National Wildlife Refuge (NRNWR) and ecologically significant stream segments located upstream of the proposed intake site.

The proposed pipeline route would cross a TPWD designated ecologically significant stream segment and areas of bottomland hardwoods. A large portion of the pipeline route occurs within forested areas, but it also would cross areas of agricultural use including crops and pasture. Impacts to preferred habitats would be minimized by utilizing agricultural areas which have been previously disturbed. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that would be affected by the pipeline corridor. These areas are commonly utilized by many different species and would be avoided as much as reasonably possible. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities would help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, any impacts to existing habitat are anticipated to be low.

---

[29] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[30] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[31] Texas Parks and Wildlife Department. (2024). *Texas Natural Diversity Database (TXNDD)*. Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[32] Texas Parks and Wildlife Department. (2024). Rare, Threatened, and Endangered Species of Texas (RTEST). Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[33] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

7.7.1.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Neches Run-of-River strategy will comply with TCEQ environmental flow standards and will leave adequate flows in the Neches River to sustain a healthy ecosystem.

7.7.1.5.3 BAYS AND ESTUARIES

The Neches River flows into Sabine Lake and the Sabine Lake Estuary downstream, which experiences an average annual flow of 4.6 million acft/year. Since the Upper Neches Project would only divert 47,500 acft/year from the river, the proposed pipeline would have very limited effects on freshwater inflow to the lake and estuary with long-term average freshwater inflows to the Sabine Lake Estuary being reduced by just over 1.0 percent.

7.7.1.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-33 represent all species federally or state listed as threatened or endangered, a federal candidate, and proposed species in the counties for which the project will be located. The project area includes 25 species that meet these criteria (IPaC and species county lists). These species would need to be considered and potentially mitigated for during project permitting and implementation. Additionally, the USFWS has identified proposed critical habitat for two species, the proposed threatened Louisiana pigtoe and the proposed endangered Texas heelsplitter. Both occur in the Neches River, which would be bisected by the proposed pipeline. These species are currently proposed and awaiting listing, so they do not currently require additional coordination and mitigation. However, these species should be monitored in case their status changes before or during construction. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.7.1.5.5 WETLANDS

The proposed pipeline passes through approximately 14 acres of NWI mapped wetlands, including the Neches River and dozens of named creeks and streams in the Neches River Basin. Although a number of NWI-mapped wetlands occur along the proposed pipeline corridor, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas.

7.7.1.5.6 AGRICULTURAL AND NATURAL RESOURCES

Within a 50-foot buffer of the proposed pipeline, the project would impact approximately 36 acres of soils identified by the USDA as prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because these areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the other Environmental Impacts sections above.

Table 7-33. Environmental Factors for Upper Neches Project

Environmental Factors	Comment(s)
Habitat	Siting and BMPs would be used to avoid or minimize impacts to sensitive habitats. Low Impacts
Environmental Water Needs	Will comply with TCEQ flow standards. Low Impacts
Bays and Estuaries	Long term average inflows reduced by 1%. Low Impacts
Threatened and Endangered Species	Tricolored bat (FPE), piping plover (FT, ST), red-cockaded woodpecker (FE, SE), rufa red knot (FT, ST), alligator snapping turtle (FPT, ST), Louisiana pigtoe (FPT, ST), Texas heelsplitter (FPE, ST), monarch butterfly (C), Neches river rose-mallow (FT, ST), white-faced ibis (ST), wood stork (ST), swallow-tailed kite (ST), Bachman's sparrow (ST), paddlefish (ST), western creek chubsucker (ST), Rafinesque's big-eared bat (ST), black bear (ST), Louisiana black bear (ST), Texas horned lizard (ST), northern scarlet snake (ST), Texas pigtoe (ST), sandbank pocketbook (ST), southern hickorynut (ST), Trinity pigtoe (ST), small-headed pipewort (ST) Proposed critical habitat for two species is present within the proposed pipeline alignment. Medium Impact
Wetlands	14 acres of wetlands along pipeline corridor Low Impact
Agriculture and Natural Resources	Potential impacts to 36 acres of prime farmland soils that will be allowed to return to original land uses. Low Impact

Source: USFWS, 2024 and TPWD 2024
FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened.
C = Candidate for Federal Listing.

7.7.1.6 CONFIDENCE AND PERMITTING

The Neches Run-of-River strategy would pose several permitting challenges along with the typical challenges associated with a new project. Similar to other new water projects in Texas, a surface water permit for the channel dam and river diversion from the Neches River would be required from TCEQ and would need to include an inter-basin transfer authorization. In addition to the surface water permit, a Section 404 permit from the USACE for impacts to a waters of the U.S. from construction activities would likely be needed for the construction of the diversion facilities and pipeline. The potential permitting requirements are shown in Table 7-34.

7.7.1.7 FLEXIBILITY AND PHASING

As with any project, there are inherent risks to eventual implementation and development. These risks can be permitting risks, mitigation risks, performance risks, and/or risks associated with various types of conflict. The Upper Neches Project is susceptible to performance risk associated with a worse drought of record. This is mitigated somewhat by the conjunctive system operation with Lake Palestine. However, a drought worse than the drought of record could reduce the water availability described in this section.

Alternative variations of this project have been identified that could help address the potential risks. In addition to the run of the river strategy described above which utilizes water stored in Lake Palestine to firm up the Neches run-of-the-river water, other alternative strategies were evaluated. One utilized a potential off channel reservoir (OCR) to firm up the run-of-the-river water and another used local groundwater from the Queen City, Carrizo and Wilcox aquifers to firm up run-of-the-river water. Additional information on these alternatives can be found in the Upper Neches River Water Supply Project Feasibility Study (HDR, 2014).

Table 7-34. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit	TCEQ	Will require authorization for the channel dam, diversion of water and an inter-basin transfer to the Trinity Basin.
Section 404	USACE	Required for construction activities in waters of the U.S.

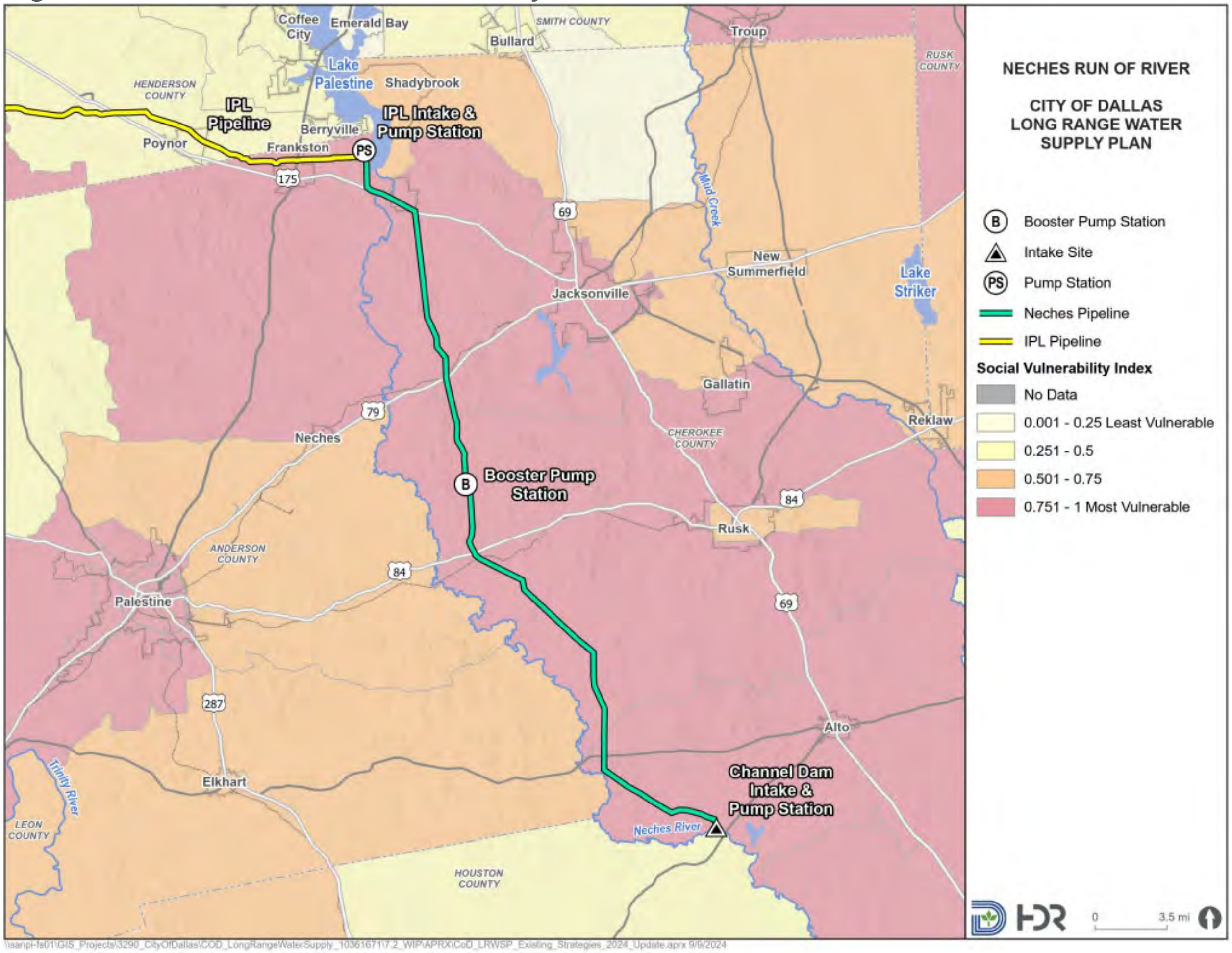
7.7.1.8 EQUITY IMPACTS

Impacts to equity from implementation of the Neches Run-of-River strategy may result from placement of potential project infrastructure such as the diversion dam, intake, pump stations, and transmission pipelines. Equity was evaluated by looking at the percent area of project components located within each quartile of the CDC's Social Vulnerability Index (see Table 7-23 and Figure 7-24). All of the project infrastructure is located in the 4th quartile of the CDC's SVI, which means that the infrastructure for this project is entirely located in areas likely to experience significant equity impacts.

Table 7-35. Neches Run-of-River SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
0.0%	0.0%	0.0%	100%	**1**

Figure 7-24. Neches Run-of-River Project Infrastructure in Relation to the CDC's SVI



7.7.2 Lake Columbia

Lake Columbia was a recommended strategy in the 2014 LRWSP. After reevaluation, this strategy has been designated as a recommended strategy again in the 2024 LRWSP.

Lake Columbia is a proposed reservoir project (previously known as Lake Eastex) of the Angelina and Neches River Authority (ANRA) and is a recommended strategy in the 2021 East Texas Regional Water Plan (Region I RWP). ANRA has been granted a water right permit (Permit No. 4228) by the TCEQ to impound 195,500 acft in a new reservoir and to divert 76 MGD (85,507 acft/yr) for municipal and industrial purposes. The 2024 LRWSP estimates that after considering local needs, approximately 50 MGD of supply would be available to Dallas.

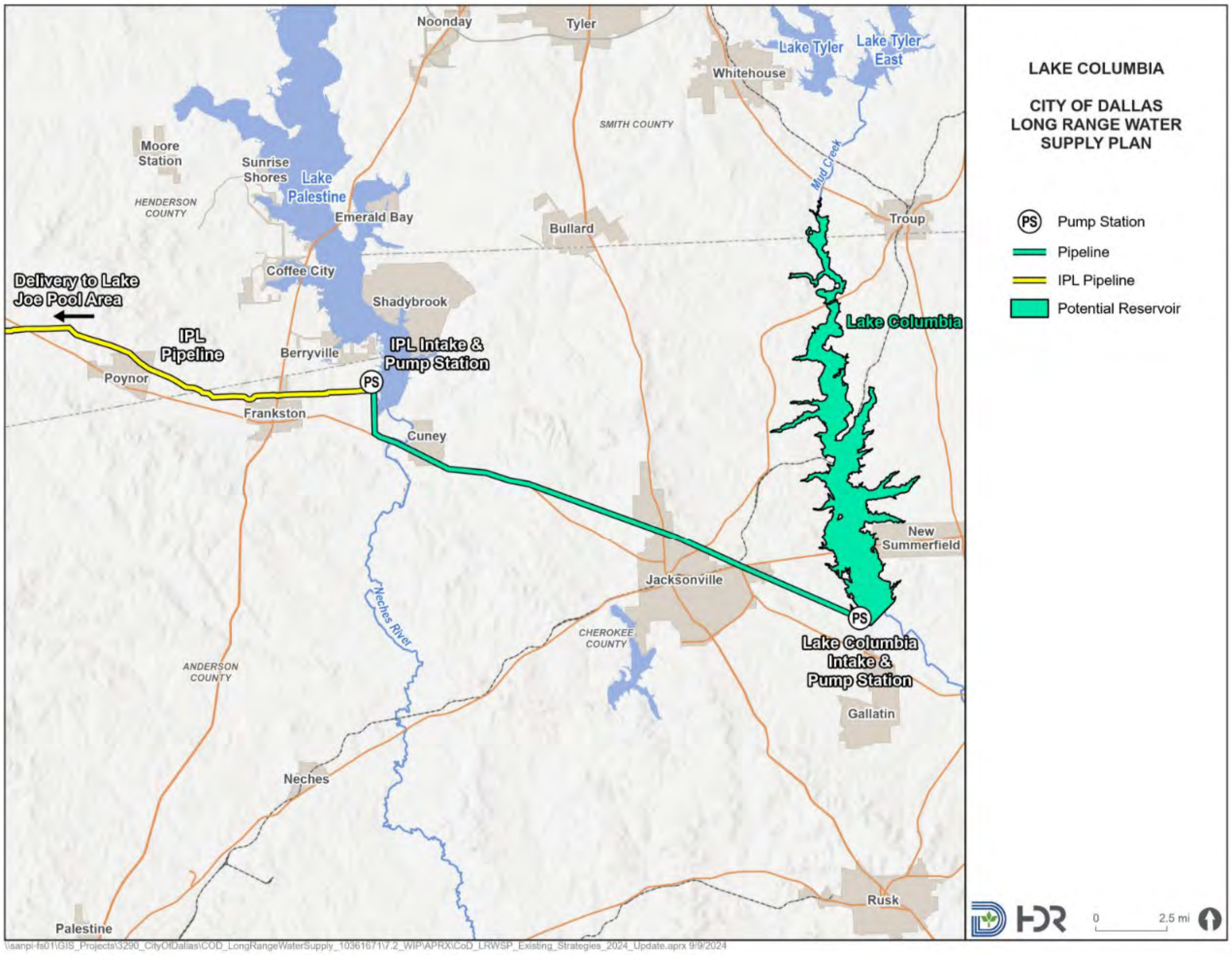
7.7.2.1 STRATEGY DESCRIPTION

Lake Columbia would be connected to Dallas' western system via pipeline from the proposed reservoir to the IPL pump station at Lake Palestine. Water would then be delivered to the Lake Joe Pool area via the IPL. Dallas' capacity in the IPL is 150 MGD and, after consideration of Dallas' Lake Palestine supply of 102 MGD, the IPL will initially have available excess capacity of about 48 MGD. It is reasonable for Dallas to potentially contract for up to 50 MGD of supply from Lake Columbia with consideration of the potential for Dallas to manage pumping rates from both Lakes Palestine and Columbia since the IPL only has an available excess capacity of 48 MGD.

The cost split is subject to future negotiations between Dallas and ANRA. Although for the purpose of this study, the assumption was made that Dallas will be responsible for 70 percent of the dam, reservoir land acquisition, and relocations, and the local entities involved in the project will be responsible for the remaining 30 percent of these costs.

The Lake Columbia dam site is located on Mud Creek, approximately three miles downstream of U.S. Highway 79 in Cherokee County, Texas. Figure 7-25 provides the location of the project and the preliminary route of the 20-mile, 54-inch diameter pipeline to the IPL pump station at Lake Palestine. The proposed dam site has a contributing drainage area of 384 square miles of which 107 square miles is controlled by the existing Tyler lakes in the upper portion of the watershed. At the authorized conservation pool capacity of 195,500 acft, Lake Columbia's conservation pool would have a water surface elevation of 315 ft-msl and inundate 10,133 acres with its flood pool affecting an additional 1,367 acres.

Figure 7-25. Lake Columbia Project



7.7.2.2 WATER AVAILABILITY

In depth water availability analysis was conducted for Lake Columbia since this project is the only 2024 LRWSP recommended strategy that involves a large, proposed reservoir. The effects from critical drought periods were a concern in this area since Lake Columbia is not an existing supply, and evaluation was needed to determine if Lake Columbia would be a reliable supply. A water availability analysis was performed for Lake Columbia using streamflows from Dallas' Water Supply model for the 1907 to 2020 period as translated from the Lake Palestine watershed to the Lake Columbia watershed using a drainage area ratio. Reservoir pass-throughs for downstream senior water rights were conservatively estimated to be the 90^{th} percentile of monthly historical pass-throughs occurring in the TCEQ Neches Water Availability Model (WAM) from 1940 to 2018. Operations of the Tyler lakes were included in the water availability analysis considering the senior priority date to Lake Columbia and other authorized diversions.

Yields for Lake Columbia were estimated using permitted storage and 2080 conditions for net evaporation considering an +8 degree Fahrenheit (F) increase from historical conditions. Yields were calculated for four critical drought periods which include the 1908 drought, the 1950's drought, the 1960's drought, and the recent (2010-2014) drought.

For Lake Columbia, the 1908, 1960's and recent droughts were all more severe than the 1950's drought.

Table 7-36 summarizes Lake Columbia firm yields for 2080 conditions for the four previous droughts and the resulting percentages considering Dallas' potential purchase of 50 MGD (56,000 acft/yr). For the 101-year period of record, the recent (2010-2014) drought proved to be the critical drought for Lake Columbia. The results show that for 2080 conditions, the firm yield of Lake Columbia does not drop below Dallas' proposed contract amount of 50 MGD for any of the historical droughts. For purposes of this analysis, it was assumed that Dallas' supplies remain whole at 50 MGD with any reductions applying to the local users.

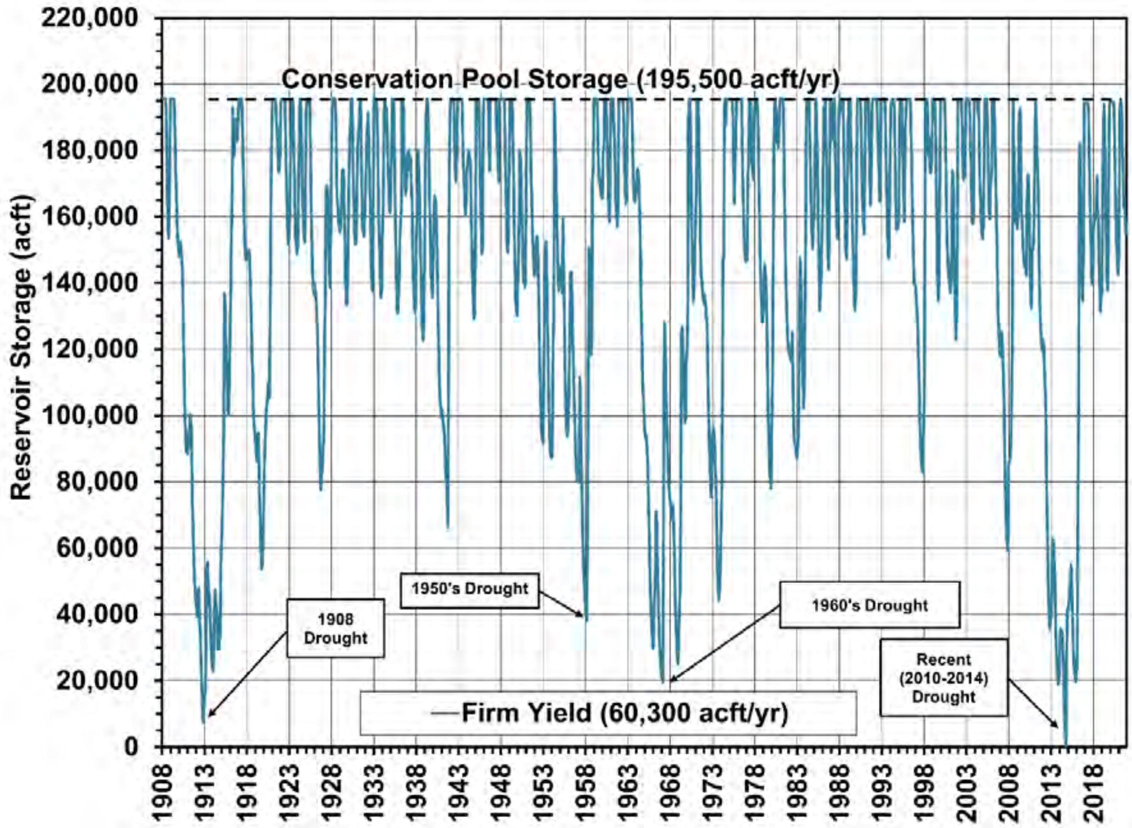
Table 7-36. Lake Columbia Firm Yield Summary

Drought	Firm Yield 2080 Conditions [a]	DWU's Percentage of 2080 Firm Yield
1908	56.5	88%
1950s	62.2	80%
1960s	59.6	84%
Recent Drought (2010-2014)	53.8	93%

[a] 2080 firm yield assumes permitted storage and +8°F increase in temperature.

Figure 7-26 presents the Lake Columbia storage trace for 2080 conditions under the recent drought (2010-2014) firm yield demand of 53.8 MGD (60,300 acft/yr). It is estimated that about 53.2 of the 53.8 MGD firm yield could be available to Dallas after considering local needs from 2026 Region I data, however, the supply available to Dallas from the Lake Columbia project is limited to 50 MGD due to IPL capacity.

Figure 7-26. Lake Columbia Storage Trace for 2080 Conditions and 2010-2014 Drought Firm Yield Demand



Note: 2080 firm yield assumes permitted storage and +8°F increase in temperature.

7.7.2.3 PROJECT COST ESTIMATE

Table 7-37 provides a planning level cost estimate for Dallas' portion of the Lake Columbia project to deliver 50 MGD (56,000 acft/yr) to the Joe Pool area. This estimate is based on Dallas being responsible for 70 percent of the cost for the dam, relocations, and reservoir land acquisition and fully responsible for costs associated with transmission facilities. The actual percent distribution of the project costs will be determined based on the future negotiations between ANRA and other participants.

Capital costs for the dam and relocations were extracted from the 2021 Region I RWP and indexed to reflect September 2023 dollars. Included in the relocation costs are estimates for four state highways and one railway that would be impacted by the reservoir. Annual costs for the project assume a 40-year reservoir debt service with 3.5% interest rate and a 20-year debt service with 3.5% interest rate for relocations and transmission facilities.

Transmission costs include the transport of supplies to the IPL pump station at Lake Palestine via a 54-in pipeline and also include energy costs to deliver the water to the Joe Pool area through the IPL. No capital improvements to the IPL were included. These costs do not include treatment and distribution costs once the water is delivered to the

Joe Pool area. It is assumed that Dallas would be responsible for 70 percent of the operation and maintenance of the dam and fully responsible for operation and maintenance costs of the transmission facilities.

An annual cost of $60.2 million is estimated to deliver 50 MGD of supplies from Lake Columbia at a unit cost of $1,076 per acft or $3.30 per 1,000 gallons. After the debt service is retired, the unit cost of water would be reduced to $312 per acft or $0.96 per 1,000 gallons.

Table 7-37. Cost Estimate Summary for Lake Columbia project (Dallas' Share)

Table units: September 2023 Dollars

Item	*Estimated Cost for Dallas' Share of Facilities*
CAPITAL COST	
Dallas' Portion of Dam and Reservoir (70% of Total Dam and Reservoir Cost)	$45,860,000
Intake and Pump Stations (52.6 MGD)	$65,870,000
Transmission Pipeline (54 in. dia., 20 miles)	$150,239,000
Dallas' Portion of Relocations (70% of Total Relocations Cost)	$98,596,000
TOTAL COST OF FACILITIES	**$360,565,000**
OTHER PROJECT COSTS	
Engineering:	
- Planning (3%)	$10,817,000
- Design (7%)	$25,240,000
- Construction Engineering (1%)	$3,606,000
Legal Assistance (2%)	$7,211,000
Fiscal Services (2%)	$7,211,000
Pipeline Contingency (15%)	$22,536,000
All Other Facilities Contingency (20%)	$42,065,000
Environmental & Archaeology Studies and Mitigation	$113,731,000
Land Acquisition and Surveying (8,538 acres)	$31,402,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$60,638,000
TOTAL COST OF PROJECT	**$685,022,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$32,334,000
Reservoir Debt Service (3.5 percent, 40 years)	$10,4331,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$2,488,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,647,000
Dam and Reservoir (1.5% of Cost of Facilities)	$688,000
Pumping Energy Costs (0.09 $/kW-hr)	$3,642,000
Delivery through IPL (180,000 $/MGD)	$8,992,000
TOTAL ANNUAL COST	**$60,234,000**
Available Project Yield (acft/yr)	56,000
Annual Cost of Water ($ per acft), based on PF=1	$1,076
Annual Cost of Water After Debt Service ($ per acft), based on PF=1	$312
Annual Cost of Water ($ per 1,000 gallons), based on PF=1	$3.30
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1	$0.96

7.7.2.4 WATER QUALITY

Water quality was evaluated, and it was found that there are no drinking water impairments. Mud Creek, which Lake Columbia is located on, is currently listed on the TCEQ 303(d) list for bacteria and depressed dissolved oxygen, however, this designation is not expected to impact treatability.

7.7.2.5 ENVIRONMENTAL IMPACTS

A preliminary desktop review of publicly available data was conducted which included USFWS NWI Database[34] and IPaC[35]; TPWD TXNDD[36] and county species list[37]; EMST[38]; and the USGS NHD[39]. Table 7-38 provides a summary of known environmental factors that have previously been considered in the draft environmental impact statement (EIS) completed by the USACE. It appears that as of 2024, USACE has not finalized the EIS for this proposed project.

7.7.2.5.1 HABITAT

The footprint of the Lake Columbia Reservoir would affect approximately 4,387 acres of wetlands and 4,353 acres of bottomland hardwoods and includes a unique habitat area consisting of an herbaceous seepage bog. The proposed pipeline route would cross one TPWD designated ecologically significant stream segment. A portion of the pipeline route occurs within forested areas, but it also crosses areas of agricultural use including crops and pasture (EMST). Impacts to preferred habitats would be minimized by utilizing the agricultural areas which have been previously disturbed. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that would be crossed by the pipeline corridor. These areas are utilized by many different species and should be avoided as much as reasonably possible. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities will help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats.

---

[34] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[35] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[36] Texas Parks and Wildlife Department. (2024). *Texas Natural Diversity Database (TXNDD)*. Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[37] Texas Parks and Wildlife Department. (2024). Rare, Threatened, and Endangered Species of Texas (RTEST). Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[38] Texas Parks and Wildlife Department. (2024). Ecological Mapping Systems – Landscape Ecology program (EMST). Retrieved from TPWD: https://tpwd.texas.gov/landwater/land/programs/landscape-ecology/ems/

[39] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

7.7.2.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Lake Columbia project would comply with TCEQ Permit No. 4228 which does not currently require instream flow releases, and the project could have a significant impact on daily flows on Mud Creek. For Dallas to import water supplies from Lake Columbia, an amendment to Permit No. 4228 would be required to allow the interbasin transfer of water to the Trinity River Basin and could make Lake Columbia subject to recently adopted TCEQ instream flow standards.

7.7.2.5.3 BAYS AND ESTUARIES

Average annual flow into Sabine Lake and the Sabine Lake Estuary downstream is approximately 4.6 million acft/year. The Lake Columbia project would have a minimal effect on freshwater inflow to Sabine Lake and the Sabine Lake Estuary. Lake Columbia, as permitted, would have less than a 5 percent impact to inflows to Sabine Lake and the Sabine Lake Estuary. This impact would be further reduced if instream flow releases are required when Permit No. 4228 is amended for interbasin transfers.

7.7.2.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-38 represent all species federally or state listed as threatened or endangered, and federal candidate and proposed species in the counties for which the project will be located. The project area includes 29 species that meet these criteria (county species lists and IPaC). These species would need to be considered through the design process and could potentially require mitigation measures during project permitting and implementation. USFWS has identified potential critical habitat for two species within the proposed project area, Louisiana pigtoe (potential threatened) and Texas heelsplitter (potential endangered). Both have potential critical habitat within the Neches River, which would be bisected by the proposed pipeline south of Lake Palestine. Since both species are only proposed for listing under the ESA, no mitigation or consideration is currently required. However, these species should be monitored in case of changes to their status before or during construction. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the pipeline portion of the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.7.2.5.5 WETLANDS

The footprint of the project would have significant impact to NWI mapped wetlands located in the area. The proposed footprint of Lake Columbia would inundate more than 10,000 acres along Mud Creek. Approximately 4,387 acres of the 10,000 are listed by NWI as wetlands. It is anticipated that the wetlands present in the reservoir footprint would require mitigation before for the 404 permit is granted.

Although 170 acres of NWI wetlands occur along the proposed pipeline corridor, flexibility in the pipeline placement would be used to minimize or avoid potential impacts to the majority of these areas.

7.7.2.5.6 AGRICULTURAL AND NATURAL RESOURCES

The Lake Columbia and transmission pipeline would temporarily or permanently impact an estimated 1,159 acres of soils identified by the USDA as prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above and in the Draft EIS.

Table 7-38. Environmental Factors for the Lake Columbia Project

Environmental Factors	Comment(s)
Habitat	Unique habitat is types are located in project area such as bottomland hardwoods and herbaceous seepage bog. High impact.
Environmental Water Needs	Interbasin transfer could open up the permit to new TCEQ environmental flow standards. Medium Impact.
Bays and Estuaries	Low Impact
Threatened and Endangered Species	Tricolored bat (FPE), piping plover (FT, ST), red-cockaded woodpecker (FE, SE), rufa red knot (FT, ST), alligator snapping turtle (FT, ST), Louisiana pigtoe (FPT, ST), Texas fawnsfoot (FT, ST), Texas heelsplitter (FPE, ST), monarch butterfly (C), Neches River rose-mallow (FT, ST) white-faced ibis, (ST), wood stork (ST), swallow-tailed kite (ST), black rail, (ST), Bachman's sparrow (ST), paddlefish (ST), western creek chubsucker (ST), Rafinesque's big-eared bat (ST), black bear (ST), Louisiana black bear (ST), Texas horned lizard (ST), northern scarlet snake (ST), Brazos water snake (ST), Texas pigtoe (ST), sandbank pocketbook (ST), southern hickorynut (ST), Brazos heelsplitter (ST), Trinity pigtoe (ST), small-headed pipewort (ST) Potential critical habitat identified within project area for the Louisiana pigtoe and the Texas heelsplitter. Medium impact
Wetlands	High impact due to a high number of potential wetlands and potential bottomland hardwoods.
Agricultural and Natural Resources	Temporary or permeant impacts to 1,159 acres of USDA prime farmland soils. Low impact

USFWS, 2024 and TPWD 2024
FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing. Source:

7.7.2.6 CONFIDENCE AND PERMITTING

ANRA is seeking a Section 404 Permit from the U.S Army Corp of Engineers. In January 2010, ANRA released a draft EIS for Lake Columbia. The EIS underwent public comment in the first half of 2010. The Lake Columbia project is subject to completion of the EIS and issuance of the Section 404 permit from the USACE, as well as completion of a Source Water Assessment. According to the April 27, 2011 statement from USACE, a new Draft EIS is necessary before a new EIS can be finalized. There have been no updates from the USACE since the date of the statement. The consideration of the Draft EIS by USACE will likely involve additional studies and compliance with the USACE Mitigation Manual. The potential permitting requirements are shown in Table 7-39.

Permit No. 4228 granted by the TCEQ does not include the right to use Lake Columbia supplies outside of the Neches River basin. If Dallas were to participate in the Lake Columbia project, an interbasin transfer (IBT) amendment would be necessary. If ANRA amends the Lake Columbia permit to authorize an IBT from the Neches to the Trinity River Basin, then the authorized diversion of 76 MGD (85,507 acft/yr) of Lake Columbia could be subject to the environmental flow standards of Texas Administrative Code, Chapter 298, Subchapter C. These standards in combination with the requirements to mitigate environmental impacts associated with the completion of the EIS and the issuance of the Section 404 permit, would likely result in a reduction in the yield of Lake Columbia.

Table 7-39. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit Amendment	TCEQ	Requires an inter-basin transfer authorization for Dallas to transport and use the water in the Trinity River Basin.
Section 404	USACE	Required for construction activities in waters of the U.S. and will require completion of the current/previous EIS process. Likely to include a source water assessment.

7.7.2.7 FLEXIBILITY AND PHASING

The Lake Columbia Project is susceptible to performance risk associated with a worse drought of record, storage losses from sedimentation and potential future increases in temperature resulting in increased reservoir evaporation. Permitting and mitigation risks are considered high for the Lake Columbia project due to the challenges associated with finalizing the EIS and obtaining the Section 404 permit.

At this time, the proposed Lake Columbia project is in the Pre-Construction Phase, and has several potential local participants. According to the ANRA, those participating in the Pre-Construction Phase will have a right of first refusal to enter into contracts for the next phases of construction and operation of Lake Columbia. At this time, the Texas Water Development Board is a 47% participant with a right of first refusal to 35.9 MGD (40,188 acft/yr) of permitted supplies. The Construction Phase is scheduled to begin after the issuance of the Section 404 Permit.

This project is limited in configuration with one intake and one delivery pipeline connecting the IPL at Lake Palestine. The water rights for the proposed reservoir have already been obtained and the project location has already been evaluated and is in the process of receiving a Section 404 Permit.

7.7.2.8 EQUITY IMPACTS

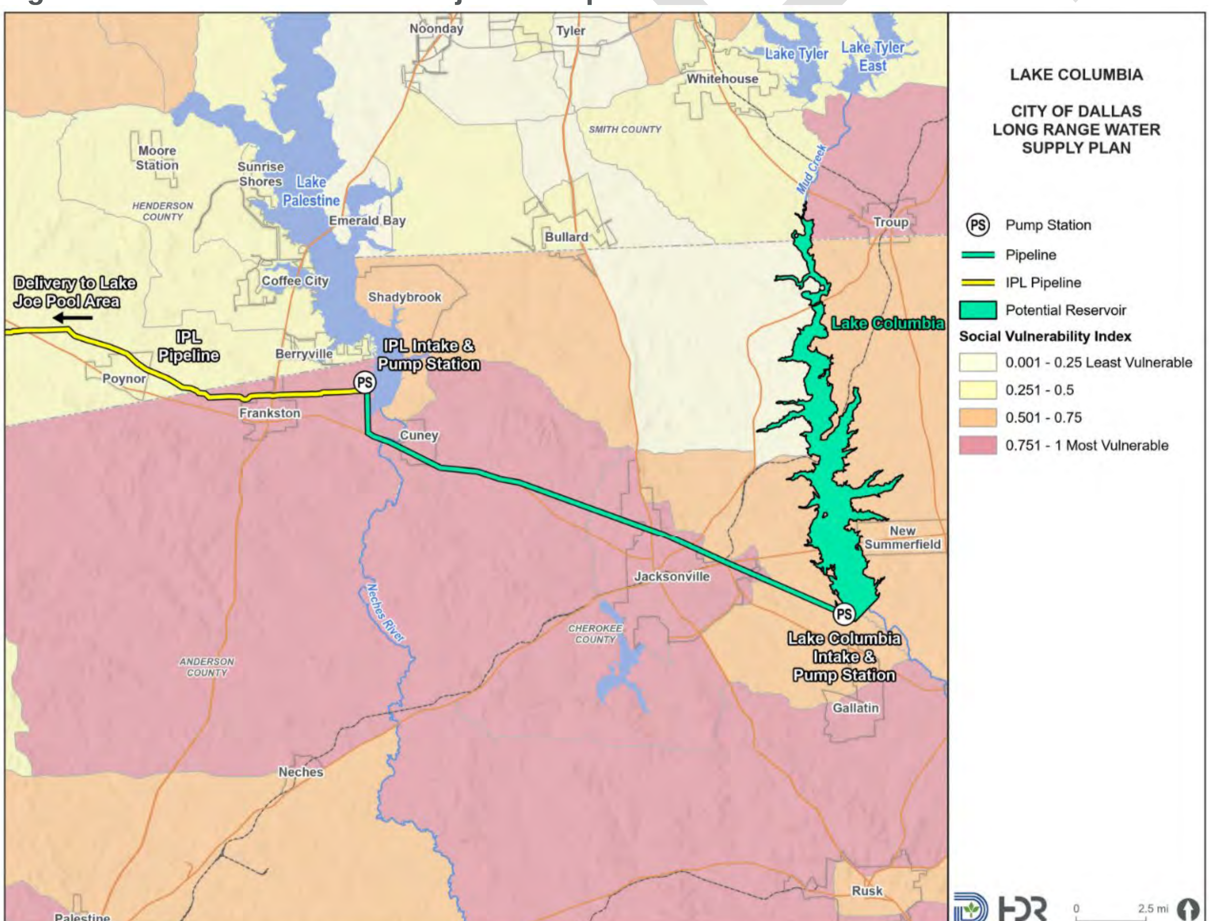
Impacts to equity from implementation of the Lake Columbia strategy may result from development of the reservoir and dam, relocations, and transmission pipeline.

Equity was evaluated by looking at the amount of area per quartile where project components are proposed to be located. The land area required for the reservoir and pipeline were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-40. A visual representation of the quartile distribution is shown in Figure 7-27.

Table 7-40. Lake Columbia SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
16.5%	1.4%	77.8%	4.3%	**1**

Figure 7-27. Lake Columbia Project Footprint with SVI Visual



Based on the results, over three quarters of the project area is projected to reside in areas with an increased vulnerability to equity impacts. The large distribution of project area residing in the 3rd quartile indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 1 based on the equity criteria scoring guidelines and the understanding that a reservoir will bring significant permanent impacts and displacement to the surrounding communities. Third quartile communities are vulnerable, and the relocation of highways and land acquisitions have the potential to increase vulnerabilities such that the surrounding areas become more susceptible to inequities related to housing and transportation.

The scoring and quartile distribution indicates that this project may have highly negative impacts to socially vulnerable communities and may significantly increase inequity to said communities. Extreme mitigation for implementation of this strategy would be necessary to reduce the burden on socially vulnerable communities.

7.8 Sulphur Basin Project

The 2024 LRWSP draws on North Texas Municipal Water District's 2024 Marvin Nichols and Lake Wright Patman Reallocation Yield Update[40] and the Sulphur River Basin Authority's Sulphur Basin Study[41, 42] to update this water management strategy. Freese and Nichols, the consultant on the 2024 NTMWD study, provided data and strategy evaluations to the JCPD who passed the recommendations on to HDR for inclusion in the 2024 LRWSP. The information presented herein is the most up to date information on the Sulphur Basin Project available at the time of writing, but project recommendations have not yet been finalized by the JCPD.

Due to the abundance of water in the basin, the Sulphur River Basin has been the focus of numerous studies for potential development of new water supply projects. From the eastern state line of Texas, the Sulphur River flows into Arkansas and joins with the Red River, a tributary of the Mississippi River. The US Army Corps of Engineers (USACE) owns and operates Wright Patman Lake, known at one time as Texarkana Lake. Wright Patman Lake is located on the Sulphur River in Bowie and Cass Counties as shown in Figure 7-28 and was authorized as part of a comprehensive plan to reduce flood damages downstream of the reservoir.

A water supply planning study known as the Sulphur Basin Study (Sulphur study) is being conducted by the Sulphur River Basin Authority (SRBA). The JCPD includes Tarrant Regional Water District (TRWD), North Texas Municipal Water District (NTMWD), Upper Trinity Regional Water District (UTRWD), and the Cities of Dallas and

---

[40] North Texas Municipal Water District. 2024. Marvin Nichols Reservoir and Lake Wright Patman Reallocation Yield Update. FNI.

[41] Sulphur River Basin Authority, Sulphur River Basin Feasibility Study. Cost Rollup Report. FNI. July 2014. http://com.srbacdn.s3.amazonaws.com/Final%20Dec14%20Cost%20Rollup%20Report.pdf

[42] United States Army Corps of Engineers. Sulphur River Basin Overview. January 2014. http://com.srbacdn.s3.amazonaws.com/Report%201%20-%20Final%20Watershed%20Overview%20Report/Final%20Watershed%20Overview%20Report_R.pdf

Irving, along with in-basin users represented by the SRBA. The most recent report generated by this joint effort is the Freese and Nichols study prepared for NTMWD in conjunction with the rest of the JCPD.

The 2024 Sulphur Basin report for NTMWD focuses on the construction the proposed Marvin Nichols Reservoir and provides updated yields as well as costs for the project assuming those yields and capacities. This will be the focus of the 2024 LRWSP's consideration of the Sulphur Basin projects. The 2024 FNI report for NTMWD also discusses Lake Wright Patman reallocation yield scenarios, but the project infrastructure is not costed and the yields are not included in the cost analysis for the Marvin Nichols Reservoir infrastructure. For this reason, the yield and costs of the Lake Right Patman reallocation are not included in the 2024 LRWSP's Sulphur Basin Project alternative.

7.8.1 Strategy Description

The 2024 LRWSP Sulphur Basin Project strategy will focus on the construction of the proposed Marvin Nichols Reservoir. The Sulphur Basin Project, if constructed, would be shared between the JCPD members. Supplies from Marvin Nichols would be pumped into a common transmission pipeline and delivered to the JCPD members with DWU receiving its portion of the supply near Lake Ray Roberts as indicated in Figure 7-28 and Table 7-41. Wright Patman Lake reallocation yields, if secured, would be transferred by transmission pipeline from Wright Patman Lake to the Marvin Nichols pipeline and then onwards to JCPD members.

Table 7-41. Delivery Locations and Peaking Rates for Delivery of Sulphur Basin Project Supplies[43]

-	TRWD	DWU	NTMWD	UTRWD	Irving	SRBA
Peaking	1.25	1.5	1.5	1.25	1.25	--
Delivery Location	Lake Bridgeport	Trinity River & Lake Ray Roberts	Leonard WTP	Chapman and Terminal Storage	Chapman	Marvin Nichols
Total Supply	25.76%	18.64%	25.76%	5.76%	4.08%	20.00%
Export Supply	32.20%	23.30%	32.20%	7.20%	5.10%	0.00%

A reservoir at the Marvin Nichols site has been a recommended strategy for NTMWD, the UTRWD, and TRWD in the 2006 and 2011 Region C RWP and an alternative strategy for Dallas Water Utilities and the City of Irving in the 2011 RWP[44]. The Marvin Nichols site is designated as a unique reservoir site by the Texas legislature and is included as an alternative in this analysis. The 2021 Region C Water Plan and the 2024 FNI project report for NTMWD both recommend a normal pool elevation if 328 ft MSL if the Marvin Nichols Reservoir is to be constructed.

As currently operated, Wright Patman Lake provides over 2.5 million acre-feet of storage for floodwaters. Prior studies have suggested that significant additional water supply

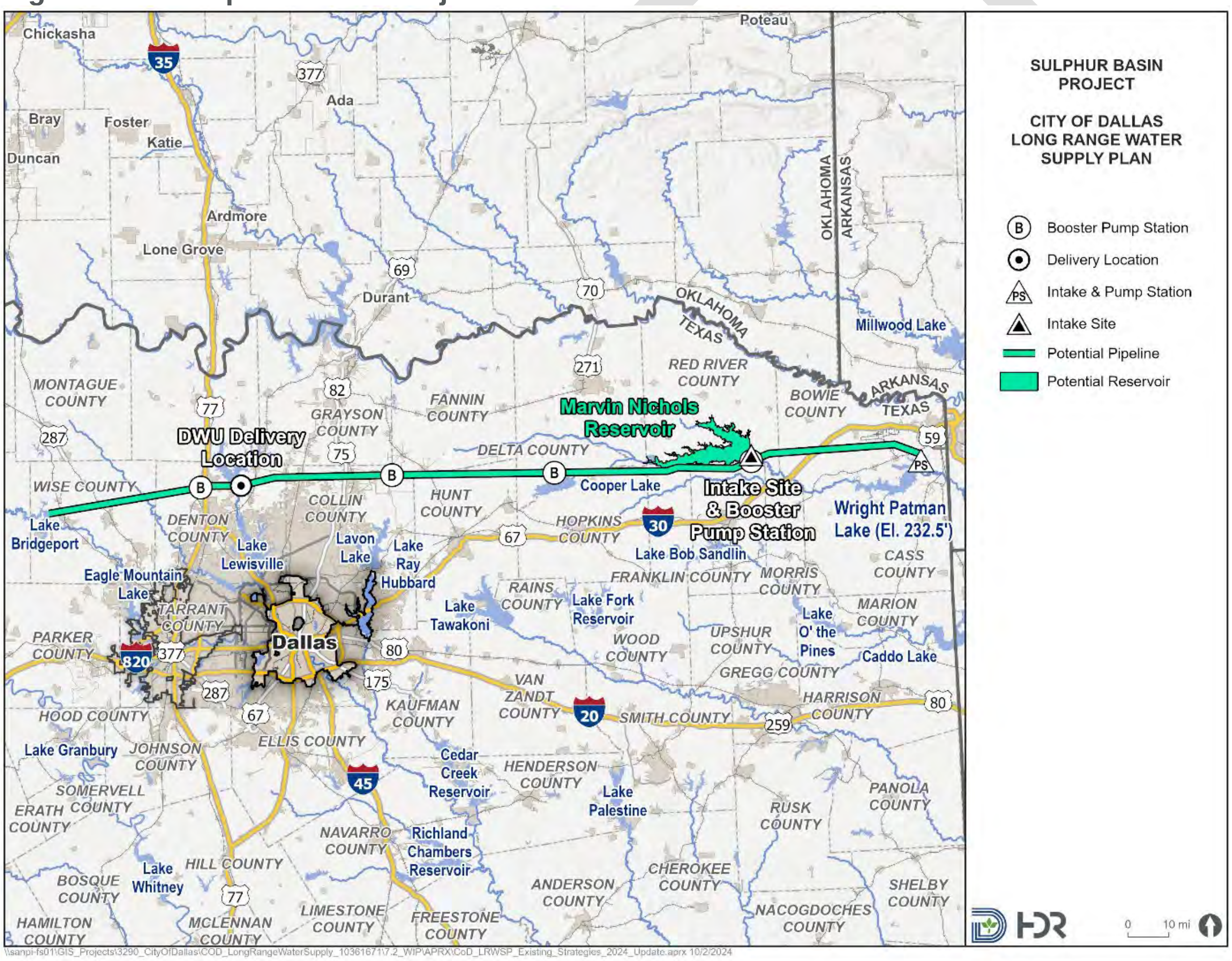
[43] North Texas Municipal Water District. 2024. Marvin Nichols Reservoir and Lake Wright Patman Reallocation Yield Update. FNI.

[44] TWDB. 2011 Region C Water Plan. October 2010

yield could be generated if a portion of the flood storage in Wright Patman Lake were reallocated to municipal use. The 2021 Region C Water Plan recommends a flat reallocation of Wright Patman Lake's Conservation pool up to 235 ft MSL. However, Texarkana applied to the TCEQ for a new 175,000 acft water right from Wright Patman Lake making the availability of Wright Patman Lake water less certain. This water right (Application 13642) is under review at the time of writing.

The Sulphur Basin Project includes an intake structure and pumpstation at the proposed Marvin Nichols Reservoir, which would require a 5.6-mile earthen dam and 7.5-mile saddle dam. Water is carried west by pipeline from that connection point to near Lake Ray Roberts requiring two booster pump stations. This is the Sulphur Basin Project's connection to the DWU system. An additional booster pump station and section of pipeline takes water further to Lake Bridgeport to be used by Tarrant Regional Water District.

Figure 7-28. Sulphur Basin Project



7.8.2 Water Availability

For the 2024 LRWSP, two scenarios are considered: a high yield scenario and a low yield scenario. The yield in both scenarios is solely the yield from the proposed Marvin Nichols Reservoir. The yields and distribution to JCPD members can be found in Table 7-42. DWU can expect 71 MGD from the high yield scenario and 63 MGD from the low yield scenario.

Table 7-42. High and Low Yield Scenarios (acft/yr)[45]

Scenario	TRWD	DWU	NTMWD	UTRWD	Irving	SRBA	Total
High Yield (acft/yr)	110,237	79,768	110,237	24,649	17,460	85,588	427,940
Low Yield (acft/yr)	97,205	70,338	97,205	21,735	15,396	75,470	377,350
High Yield (MGD)	98.35	71.17	98.35	21.99	15.58	76.36	381.79
Low Yield (MGD)	86.72	62.75	86.72	19.39	13.74	67.33	336.65

The high yield scenario uses the Lyons method to determine environmental flows; it does not assume a new Texarkana water right on Wright Patman Lake; and it does not consider a minimum 10 CFS release for Wright Patman Lake. The Low yield scenario also uses the Lyons method to determine environmental flows; it assumes the Texarkana water right is approved; and it assumes a minimum release of 10 CFS for Wright Patman Lake.

There is currently only one water right owner in Wright Patman Lake (i.e., the City of Texarkana, Texas). Texarkana has the right to impound 386,900 acre-feet of water in Wright Patman Lake and is permitted to use 161 (180,000 acft/yr). Additionally, the City of Texarkana has applied for a new 175,000 acft/yr water right. The application is pending at the time of writing. The 2024 NTMWD FNI report estimates that the JCPD could receive as much as 465 MGD (520,560 acft/yr) in combined yield scenario without the Texarkana application. This scenario is similar to the high yield scenario for Marvin Nichols. A combined yield of 338 MGD (378,620 acft/yr) is estimated for a scenario similar to the Marvin Nichols low yield scenario. These yields are not used as the Sulphur Basin Project yields because project costs from the NTMWD report do not include the capacity of the combined project.

7.8.3 Project Cost Estimate

The Sulphur Basin project will be shared between the JCPD members. The total cost to construct Marvin Nichols reservoir and construct the transmission system to deliver 305 MGD (342,000 acft/yr) is $6.6 billion. Annual costs are $538 million including debt service, operation, maintenance, and pumping costs. This represents the high yield scenario with 20% of the yield remaining in the Sulphur River Basin for in-basin use. The total cost to construct Marvin Nichols reservoir and construct the transmission system to deliver 269 MGD (302,000 acft/yr) is $6.3 billion. Annual costs are $510 million including

[45] North Texas Municipal Water District. 2024. Marvin Nichols Reservoir and Lake Wright Patman Reallocation Yield Update. FNI.

debt service, operation, maintenance, and pumping costs. This represents the low yield scenario with 20% of the yield remaining in the Sulphur River Basin for in-basin use.

Costs are shown in Table 7-43 and Table 7-44 for Dallas' portion of costs for the Sulphur Basin Project to deliver supply to the Trinity River Basin near Lake Ray Roberts in September 2023 dollars. These costs come from FNI's 2024 Cost Update for NTMWD[46] which contains the latest opinion of probable cost for the Sulphur Basin Project at the time of writing. The costs have been indexed from September 2021 dollars, the unit used by FNI, to September 2023 dollars for comparison with other strategies considered by the LRWSP.

Total project costs to Dallas are estimated to be $1,552 million for the high yield scenario and $1,472 million for the low yield scenario. Annual costs for the project assuming a 40-year debt service for reservoir facilities and a 20-year debt service for transmission facilities is estimated at $163 million per year and $152 million per year, respectively. The annual unit cost of water for high yield scenario would be about $2,038 per acft or $6.25 per 1,000 gallons. The unit cost for the low yield scenario would be $2,164 per acft, or $6.64 per 1,000 gallons. The high yield post-debt service unit cost of water would decrease to $316 per acft or $0.97 per 1,000 gallons. The low yield post-debt service unit cost of water would be $326 per acft or 1.00 per 1,000 gallons.

[46] North Texas Municipal Water District. 2024. Marvin Nichols Reservoir and Lake Wright Patman Reallocation Yield Update. FNI.

Table 7-43. Estimated Project Costs for Marvin Nichols Reservoir High Yield Scenario

Table units: September 2023 Dollars

Item	Estimated Cost for Facilities	Estimated Cost for DWU Portion of Facilities
RESERVOIR FACILITIES		
Dam and Spillway	$631,528,000	$147,146,000
Reservoir Land Acquisition (27,382 acres)	$355,600,000	$82,855,000
Reservoir Conflicts	$207,195,000	$48,276,000
Reservoir Mitigation	$1,055,083,000	$245,834,000
Reservoir Permitting	$81,150,000	$18,908,000
Reservoir Interest During Construction	$222,427,000	$51,825,000
TOTAL COST OF RESERVOIR FACILITIES	**$2,552,983,000**	**$594,845,000**
TRANSMISSION FACILITIES		
Pipeline	$2,609,906,000	$613,131,000
Pump Stations	$1,101,447,000	$260,994,000
Interest During Construction	$354,212,000	$83,426,000
TOTAL COST OF TRANSMISSION FACILITIES	**$4,065,565,000**	**$957,551,000**
TOTAL COST OF PROJECT	**$6,618,548,000**	**$1,552,396,000**
ANNUAL COST		
Non Reservoir Debt Service (3.5 percent, 20 years)	$408,133,000	$96,126,000
Reservoir Debt Service (3.5 percent, 40 years)	$177,127,000	$41,271,000
Operation and Maintenance		
Reservoir	$7,840,000	$1,827,000
Intake, Pipeline, Pump Station	$45,629,000	$10,683,000
Pumping Energy Costs (kW-hr @ 0.07 $/kW-hr)	$54,587,000	$12,690,000
TOTAL ANNUAL COST	**$693,316,000**	**$162,597,000**
Available Project Yield (acft/yr)	342,352	79,768
Annual Cost of Water ($ per acft)	$2,025	$2,038
Annual Cost of Water ($ per 1,000 gallons)	$6.21	$6.25
Annual Cost of Water after Debt Service ($ per acft)	$316	$316
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	$0.97	$0.97

Table 7-44. Estimated Project Costs for Marvin Nichols Reservoir Low Yield Scenario
Table units: September 2023 Dollars

Item	Estimated Cost for Facilities	Estimated Cost for DWU Portion of Facilities
RESERVOIR FACILITIES		
Dam and Spillway	$631,528,000	$147,146,000
Reservoir Land Acquisition (27,382 acres)	$355,600,000	$82,855,000
Reservoir Conflicts	$207,195,000	$48,276,000
Reservoir Mitigation	$1,055,083,000	$245,834,000
Reservoir Permitting	$81,150,000	$18,908,000
Reservoir Interest During Construction	$222,427,000	$51,825,000
TOTAL COST OF RESERVOIR FACILITIES	**$2,552,983,000**	**$594,844,000**
TRANSMISSION FACILITIES		
Pipeline	$2,430,054,000	$559,062,000
Pump Stations	$1,009,783,000	$241,651,000
Interest During Construction	$328,298,000	$76,420,000
TOTAL COST OF TRANSMISSION FACILITIES	**$3,768,135,000**	**$877,133,000**
TOTAL COST OF PROJECT	**$6,321,118,000**	**$1,471,977,000**
ANNUAL COST		
Non-Reservoir Debt Service (3.5 percent, 20 years)	$378,274,000	$88,053,000
Reservoir Debt Service (3.5 percent, 40 years)	$177,127,000	$41,271,000
Operation and Maintenance		
Reservoir	$7,840,000	$1,827,000
Intake, Pipeline, Pump Station	$43,384,000	$9,810,000
Pumping Energy Costs (kW-hr @ 0.07 $/kW-hr)	$48,035,000	$11,261,000
TOTAL ANNUAL COST	**$654,660,000**	**$152,222,000**
Available Project Yield (acft/yr)	301,880	70,338
Annual Cost of Water ($ per acft)	$2,169	$2,164
Annual Cost of Water ($ per 1,000 gallons)	$6.65	$6.64
Annual Cost of Water after Debt Service ($ per acft)	$329	$326
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	$1.01	$1.00

7.8.4 Water Quality

The Sulphur River at the proposed Marvin Nichols Reservoir site has no drinking water impairments reported by the TCEQ or EPA. This reach of the river is on the TCEQ's 303(d) list for depressed levels of dissolved oxygen and for pH. These impairments are considered fish and wildlife impairments and are not expected to affect the treatability of the water. Lake Wright Patman has no listed impairments and is currently used as a drinking water source by the City of Texarkana. Texarkana Water Utilities is able to treat

Lake Wright Patman water to meet primary and secondary EPA standards as reported in their annual drinking water quality report[47].

7.8.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[48] and IPaC[49]; TPWD, TXNDD[50] and species county lists[51]; and the USGS NHD[52]. Table 7-45 provides a summary of known environmental factors that would need to be considered during the permitting of these projects. These categories provide a general summary of these conditions and further study would be needed during permitting to address these potential concerns with the respective regulatory agencies.

7.8.5.1 HABITAT

The footprints of both the Wright Patman and Marvin Nichols projects contain heavily forested areas, agricultural areas including crops and pasture, and thousands of acres of riverine and wetland habitat. Impacts to preferred habitats within the reservoir areas will be minimized to some extent by utilizing the agricultural areas which have been previously disturbed as much as practicable. No designated critical habitat currently occurs within these project areas. The Wright Patman project area includes a significant amount of wetland and bottomland hardwood areas. The Sulphur Basin Study[53, 54] data reported that 12,525 acres of Waters of the U.S. (WOTUS) would be impacted by Wright Patman. In addition, Atlanta State Park and White Oak Creek Wildlife Management Area are located within the proposed project area. This project area also includes a TPWD designated ecologically significant stream segment of the Sulphur River, and barren areas which are considered to be a unique habitat type.

Marvin Nichols Reservoir as proposed includes several thousand acres of wetland vegetation, about 25,000 acres of bottomland hardwood and prairie vegetation, and

---

[47] Texarkana Water Utilities. 2022. 2022 Annual Drinking Water Quality Report (Consumer Confidence Report). https://twu.txkusa.org/files/documents/CCR202214123018051223PM.pdf

[48] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[49] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[50] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[51] Texas Parks and Wildlife Department. (2024). Rare, Threatened, and Endangered Species of Texas (RTEST). Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[52] US Geological Survey. (2019). National Hydrography Dataset. Retrieved from ESRI.

[53] Sulphur River Basin Authority, Sulphur River Basin Feasibility Study. Cost Rollup Report. FNI. July 2014. http://com.srbacdn.s3.amazonaws.com/Final%20Dec14%20Cost%20Rollup%20Report.pdf

[54] United States Army Corps of Engineers. Sulphur River Basin Overview. January 2014. http://com.srbacdn.s3.amazonaws.com/Report%201%20-%20Final%20Watershed%20Overview%20Report/Final%20Watershed%20Overview%20Report_R.pdf

barren areas. The Sulphur Basin Study reported that 12,151 acres of WOTUS occur within the Marvin Nichols Reservoir. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities will help to minimize potential impacts to the discussed sensitive natural areas.

7.8.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Sulphur Basin project could have an impact on daily flows in the Sulphur River below each reservoir.

7.8.5.3 BAYS AND ESTUARIES

The Sulphur Basin Project flows into the Mississippi River system. The flows diverted for the proposed project would be negligible in the Mississippi River system and would not affect flows to bays or estuaries.

7.8.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-45 represent all species federally or state listed as threatened or endangered, and federal candidate species in the affected counties. These projects include 22 species that meet these criteria. These species would need to be considered and potentially mitigated for during project permitting and implementation. No critical habitat for threatened or endangered species is present along the proposed pipeline. Considering the numbers of listed species and the large number of acres potentially affected by these two projects the impacts to species would be considered medium. The listed species within the project area counties will need to be reviewed in further detail order to determine the feasibility of the project.

7.8.5.5 WETLANDS

Including a 50-foot buffer around the proposed pipeline extent, the Marvin Nichols Reservoir and Sulphur Basin Pipeline footprints would impact a combined total of 32,395 acres of NWI-mapped wetlands, including dozens of named rivers and streams. These areas would be mitigated in accordance with required federal regulations as administered through the USACE section 404 permitting process.

7.8.5.6 AGRICULTURAL AND NATURAL RESOURCES

Within a 50-foot buffer of the proposed pipeline and including the footprint for the proposed Marvin Nichols Reservoir, the project would impact about 5,000 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils[55]. This area represents less than 1.5% of the total prime farmland in Red River, Franklin, Titus, Bowie, Cass, and Morris counties. Impacts to natural resources of the state are included in the Environmental Impacts section above.

---

[55] Insufficient soil data for Wright Patman Reservoir. However, since the area is already inundated, it is unlikely that additional soils would be designated as prime farmland.

Table 7-45. Environmental Factors for Sulphur Basin Project

Environmental Factors	Comment(s)
Habitat	Bottomland hardwood, wetland, and other sensitive habitat areas present High Impact
Environmental Water Needs	Medium Impact
Bay and Estuary	Low Impact
Threatened and Endangered Species	Tricolored bat (FPE), piping plover (FT, ST), rufa red knot (FT, ST), whooping crane (FE, SE), alligator snapping turtle (FPT, ST), Texas fawnsfoot (FT), Texas heelsplitter (FPE, ST), monarch butterfly (C), white-faced ibis (ST), wood stork (ST), swallow-tailed kite (ST), Bachman's sparrow (ST), paddlefish (ST), chub shiner (ST), western creek chubsucker (ST), blackside darter (ST), black bear (ST), Texas horned lizard (ST), northern scarlet snake (ST), Texas pigtoe (ST), sandback pocketbook (ST), southern hickorynut (ST) Medium Impact
Wetlands	Large areas of wetlands are present within both project areas High Impact

Sources: USFWS, 2024; TPWD, 2024

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. C = Candidate for Federal Listing

7.8.6 Confidence and Permitting

The Sulphur Basin project would pose several unique permitting challenges along with the typical challenges associated with a new project. Similar to other new water projects in Texas, Dallas and the other project partners would need to obtain a water rights permit for the river diversion from the TCEQ including interbasin transfer authorizations. In addition to the water rights permit, Dallas and the other project partners would need to obtain a Section 404 permit from the USACE for impacts to a waterway from construction activities, summarized in Table 7-46. It is anticipated that the size of the project and the inundation of 32,000 acres of wetlands would make acquiring the Section 404 permit difficult.

Table 7-46. Summary of Required Major Permits for Suphur Basin Project

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit	TCEQ	Will require an inter-basin transfer authorization.
Section 404	USACE	Required for construction activities in waters of the US.

7.8.7 Flexibility and Phasing

The Sulphur Basin Project possesses a high level of risk associated with permitting as discussed in Section 7.8.5. The Sulphur Basin Project is not a highly flexible project due to the scope of the work and the size of the infrastructure. The project's infrastructure size also limits its potential for phasing.

The Sulphur River is considered a reliable source of water under current conditions, but this project is susceptible to performance risk associated with a worse drought of record and future increases in reservoir evaporation from increasing temperature. The project has a limited number of configurations but has two intakes on two reservoirs. This project's utilization of two large reservoirs may offer resistance to droughts; however, the reservoirs are in series and one's condition will affect the other.

The JCPD serves as an excellent example of partnerships through a joint project but is not expected to increase the flexibility of DWU's role in the project. This again due to the scale of the project.

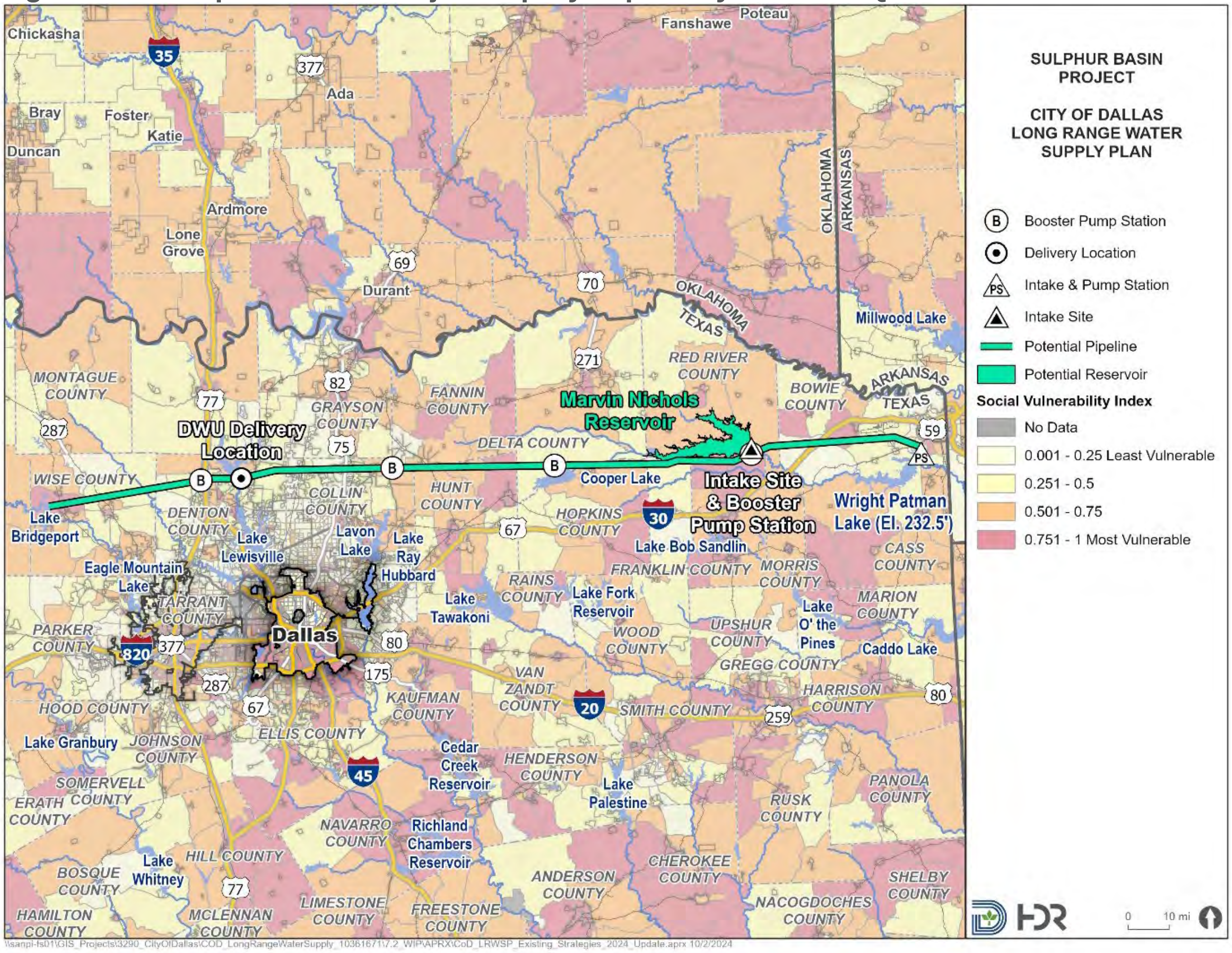
7.8.8 Equity Impacts

Impacts to equity from implementation of the Sulphur Basin Project may result from the location of project infrastructure. Construction to be considered includes: one reservoir and dam, two raw water intakes, five pump stations, and an estimated 173 miles of transmission pipeline. Impacts to equity due to the construction of the transmission pipeline may be temporary but impacts from other components should be considered permanent. The project alignment was chosen based off preliminary engineering judgment. Table 7-47 reports the percentage of project footprint area that lies in each CDC SVI quartile. A map showing the project footprint and CDC SVI data by census tract can be seen in Figure 7-29.

Table 7-47. Sulphur Basin Project Equity Impact by CDC SVI Quartile

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
0.5%	9.7%	71.5%	18.3%	2

Figure 7-29 Sulphur Basin Project Equity Impact by CDC SVI Quartile



7.9 Interstate - Little River-Millwood Lake

This is an interstate strategy that evaluates the diversion of a large supply of water from an entity in Arkansas. Little River-Millwood Lake is a new strategy evaluated in the 2024 LRWSP and has been designated as an alternative strategy.

Little River at Millwood Lake is part of Reach 2 of the Red River Compact and is located in the Southwest Arkansas river basin. The Little River begins upstream of Millwood Lake, eventually flows through Millwood Lake, and then downstream where it will confluence with the Red River.

7.9.1 Strategy Description

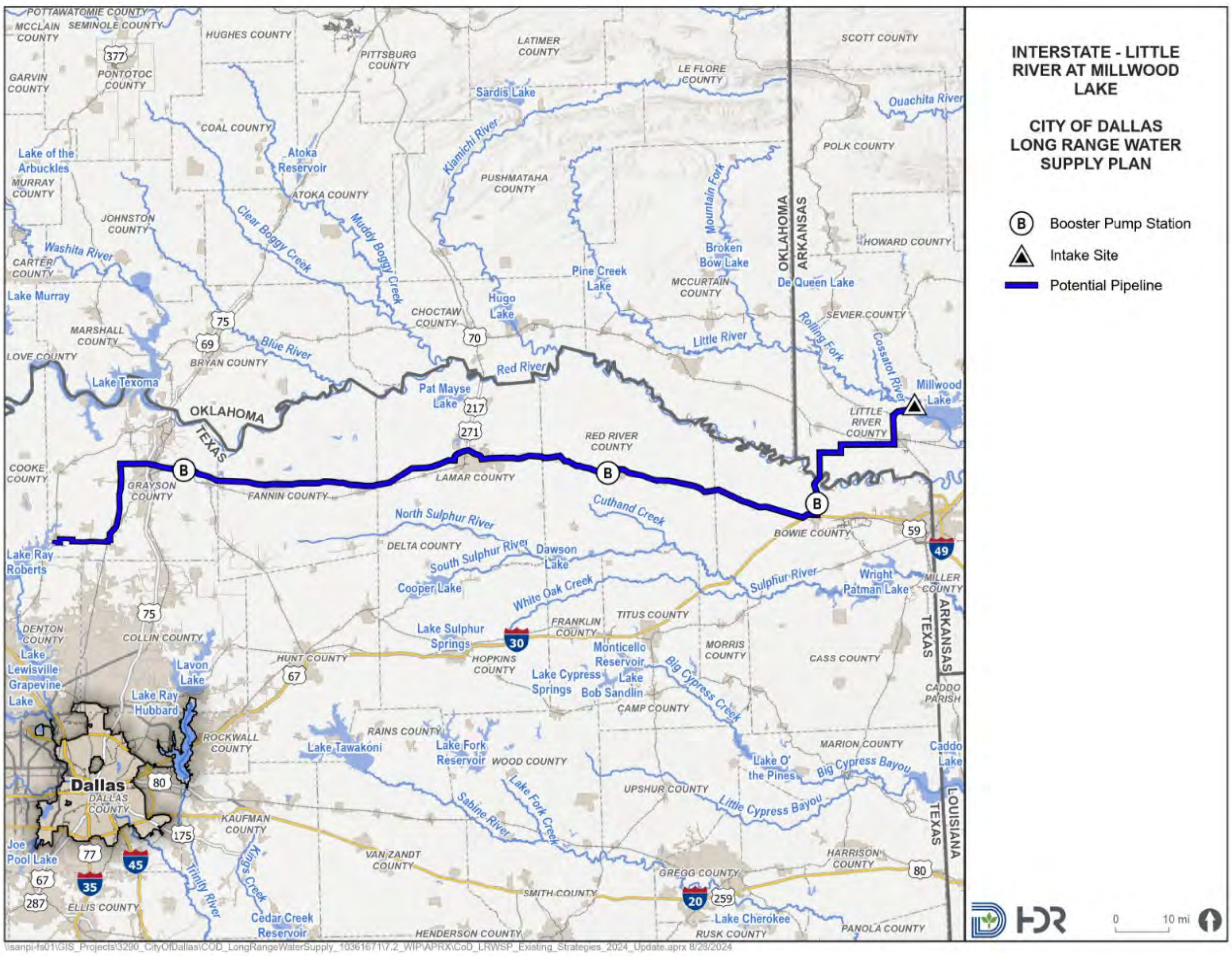
Securing water supplies from Southwest Arkansas was originally proposed and evaluated in 2014 when the Riverbend Water Resources District approached DWU with a proposal "to identify and evaluate potential water supplies and associated facilities to manage and convey water supplies from southwest Arkansas … to [Dallas]." There were multiple possible supply options, and the only strategy evaluated was securing surplus water and/or unused water rights from Millwood Lake. This option was not a recommended or alternative strategy in the 2014 LRWSP.

This water supply strategy assumes the diversion and conveyance of 268 MGD (300,000 acft/yr) of water from the Little River, upstream of Millwood Lake in Southwest Arkansas, across state lines, directly to Lake Ray Roberts.

It is assumed DWU would be able to secure a water supply agreement with an Arkansas entity based on past interest in the project from the Riverbend Water Resources District.

The channel dam and intake and pump station associated with the project would be located in Little River County, Arkansas. A 207-mile pipeline would be needed to deliver supplies from Little River to DWU at Lake Ray Roberts (Figure 7-30). An outfall structure to reduce residual head at the pipeline outlet at Lake Ray Roberts is also needed.

Figure 7-30. Interstate – Little River at Millwood Lake to Lake Ray Roberts



7.9.2 Water Availability

The water availability for this strategy is determined from gage flows at different locations on the Little River. The 2014 Arkansas Water Plan Update indicates that there is a large volume of excess water available in the Little River. The plan states that 338 MGD (378,698 acft/yr) are available at Millwood Lake for other uses or Interbasin transfers. The two gages used for this analysis were the Cossatot River near DeQueen, AR and Little River near Horatio, AR. Gage flows, water quality, fish and wildlife, navigation, and interstate compact water uses were considered in the 2014 evaluation.

Average annual gaged flows at Little River near Horatio, AR from 1969 through 2023, area-weighted average 7Q10 values from the 2008 USGS report "Low-Flow Characteristics and Regionalization of Low-Flow" (USGS 2008), and fish and wildlife flows determined by the percentage of mean monthly flow based on the season were compiled to update the water availability estimate from the 2014 Arkansas Water Plan. The average excess available flow for the period of 1969-2023 is 266 MGD (297,578 acft/yr) and the most recent 5-year period of average excess available flow is 338 MGD (378,538 acft/yr). Based on these analyses, it is assumed that 268 MGD (300,000 acft/yr) is available for purchase by DWU. The excess water available for an interbasin transfer is approximately one fourth of the total flow.

The Red River Compact does not regulate water availability upstream of Millwood Dam and the state of Arkansas has a right to unrestricted use of the water within its boundaries above Millwood Dam. Therefore, water use for this strategy will not have to comply with the terms of the Red River Compact as long as the final location of the pump station and intake is upstream Millwood Dam.

7.9.3 Project Cost Estimate

The following facilities are required to deliver water from Little River to Lake Ray Roberts:

- Channel dam and 281.2 MGD intake and pump station at Little River.
- Approximately 207 miles of 132-inch transmission pipeline from Little River to Lake Ray Roberts.
- Three booster pump stations along the pipeline route: one with 24,302 HP and two with 22,189 HP
- Outfall structure at Lake Ray Roberts

A summary of total project costs of the project for the Little River at Millwood Lake pipeline is listed in Table 7-48. The total project costs are $7.36 billion. Annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and are estimated to be $615,320,000 per year. The raw water purchase cost from Arkansas Natural Resources Commission or an Arkansas Entity would need to be negotiated as part of project implementation, and therefore not included in this cost estimate. The unit cost of water for this project is $2,051 per acft or $6.29 per 1,000 gallons. The unit cost is based on the assumed 300,000 acft of water available for purchase and excludes the raw water purchase cost.

Table 7-48. Cost Estimate Summary for Little River Pipeline to Lake Ray Roberts

Table units: September 2023 Dollars

Item	*Estimated Costs for Facilities*
	CAPITAL COSTS
Channel Dam	$12,609,000
Intake Pump Stations (281.2 MGD)	$84,853,000
Transmission Pipeline (132 in. dia., 206.5 miles)	$4,778,645,000
Transmission Pump Station(s) & Storage Tank(s)	$229,304,000
Backup Generator & Outfall Structure	$34,332,000
TOTAL COST OF FACILITIES	**$5,139,743,000**
	OTHER PROJECT COSTS
Engineering	
- Planning (3%)	$154,192,000
- Design (7%)	$359,782,000
- Construction Engineering (1%)	$51,397,000
Legal Assistance (2%)	$102,795,000
Fiscal Services (2%)	$102,795,000
Pipeline Contingency (15%)	$716,797,000
All Other Facilities Contingency (20%)	$72,220,000
Environmental & Archaeology Studies and Mitigation	$6,220,000
Land Acquisition and Surveying (2,523 acres)	$3,373,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$651,299,000
TOTAL COST OF PROJECT	**$7,360,613,000**
	ANNUAL COST
Debt Service (3.5 percent, 20 years)	$515,837,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$48,130,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$7,854,000
Dam and Reservoir (1.5% of Cost of Facilities)	$189,000
Pumping Energy Costs (0.09 $/kW-hr)	$43,310,000
TOTAL ANNUAL COST	**$615,320,000**
Available Project Yield (acft/yr)	300,000
Annual Cost of Water ($ per acft), based on PF=1.05	$2,051
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.05	$332
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.05	$6.29
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.05	$1.02

Note: One or more cost element has been calculated externally

7.9.4 Water Quality

Water quality evaluation of Little River above Millwood Lake identified no impairments to the designated uses and lists the waterbody condition as good. Beryllium, chloride, lead, nitrogen and nitrate, sulfate, and total dissolved solids were assessed for domestic water supply use and no impairments were found.

7.9.5 Environmental Impacts

To determine potential environmental issues, a preliminary desktop review of publicly available data was conducted which included USFWS NWI and IPaC databases; TPWD threatened and endangered species lists and TXNDD; and the USGS NHD. Table 7-49 below summarizes potential environmental issues for this alignment.

7.9.5.1 HABITAT

The intake pump station, pipeline, booster pump station and outfall structure will be located to avoid conflicts with environmentally sensitive areas where feasible. According to the USFWS IPaC resource list, there are currently no areas of designated critical habitat within the project area. The majority of the pipeline route crosses areas of agricultural use including crops and pasture, based on the NLCD (USGS). Impacts to preferred habitats will be minimized by utilizing these areas which have been previously disturbed where practicable. The pipeline corridor crosses the Red River, several perennial streams, and dozens of named creeks. The wooded riparian areas that occur along and adjacent to the stream and river crossings are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route may also cross wetland areas which could be disturbed during construction. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities would help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing habitat from this project are anticipated to be low.

7.9.5.2 ENVIRONMENTAL WATER NEEDS

The most recent 5-year period of average excess available flow of Little River is 378,538 acft/yr. The Little River-Millwood Lake alternative would divert 268 MGD (300,000 acft/yr), over 75% of available flow. Diversion of such a high quantity of flow would impact riparian zone and aquatic habitat health. Coordination with the Arkansas Department of Environmental Quality will be required to determine minimum streamflow and BMPs on Little River.

7.9.5.3 BAYS AND ESTUARIES

Downstream of Millwood Lake, Little River becomes a tributary of the Red River, which eventually flows into the Mississippi River Delta. At its confluence with Little River, Red River has a flow of 3.6 million acft/year. The proposed 300,000 acft/year diverted from Little River would be of negligible impact to the Mississippi River Delta's aquatic conditions.

7.9.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-49 represent all federally or state-listed species and federal candidate and proposed species in the counties for which the project will be located. The pipeline route traverses potential habitat for 27 listed species. These species would need to be considered through the design process and could potentially require mitigation measures during the project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.9.5.5 WETLANDS

Approximately 18 acres of potentially jurisdictional wetlands occur within a 50-foot buffer of the proposed pipeline corridor, based on the NWI. Although several wetlands occur, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas. Impacts to wetlands associated with this project are anticipated to be low.

7.9.5.6 AGRICULTURAL AND NATURAL RESOURCES

Within a 50-foot buffer of the pipeline, Little River to Lake Ray Roberts would temporarily or permanently impact an estimated 114 acres of soils identified by the USDA as prime farmland soils in Texas[56]. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction of the underground pipeline is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above.

[56] Farmland soil data insufficient to make a determination in Arkansas.

Table 7-49. Environmental Factors for the Interstate – Little River at Millwood Lake AR Project

Environmental Factors	Comment(s)
Habitat	No presence of critical or unique habitat in project area. Low Impact
Environmental Water Needs	High Impact
Bays and Estuaries	Low Impact
Threatened and Endangered Species	Indiana bat (FE), northern long-eared bat (FE), tri-colored bat (FPE), eastern black rail (FT, ST), piping plover (FT, ST), rufa red knot (FT), whooping crane (FE, SE), alligator snapping turtle (FPT, ST), Ouachita Rock pocketbook (FE), Texas fawnsfoot (FT), American burying beetle (FT), monarch butterfly (C), white-faced ibis (ST), wood stork (ST), swallow-tailed kite (ST), Bachman's sparrow (ST), shovelnose sturgeon (ST), paddlefish (ST), chub shiner (ST), blue sucker (ST), western creek chubsucker (ST), blackside darter (ST), black bear (ST), alligator snapping turtle (ST), Texas horned lizard (ST), northern scarlet snake (ST), Texas heelsplitter (ST) Medium Impact
Wetlands	Low to Medium Impact
Agricultural and Natural Resources	Temporary impacts to 114 acres of USDA prime farmland soils. Low impact

Source: USFWS, 2024 and TPWD 2024
FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.
ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

7.9.6 Confidence and Permitting

Water supply from Little River-Millwood Lake in Southwest Arkansas will require a water right permit from the Arkansas Natural Resources Commission (ANRC). The water rights permit can be held by DWU or by an Arkansas entity with whom DWU holds a contract for the sale of water.

The Little River is part of the Red River Compact, however, if the intake is placed above the Millwood Dam, then compliance with the Red River Compact would not be an issue due to Arkansas' right to unrestricted use of the water above Millwood Dam.

A USACE Section 404 permit from the Little Rock District will likely be required as part of the intake pump station and pipeline.

There is the potential for implementation issues while securing easements for the pipeline route within the vicinity of Millwood Lake. There is a 92,500-acre flowage easement around Millwood Lake that requires construction controls compliance and may need approval from the USACE District Engineer (US Army Corps of Engineers, 2022). It should also be noted that, depending on the final project location, a land easement for the pipeline or pump station may have to be obtained from the USACE, as they own approximately 6,500 acres of land surrounding Millwood Lake. The location of the intake, pump station, and pipeline may need to be adjusted as necessary to not interfere with

USACE easements or additional planning should be accounted for should it be necessary for project components to be located within the easement.

Potential risk associated with this strategy is the Lacey Act. The Lacey Act may inhibit this strategy should there be identification of an invasive or “injurious species” (as defined by the Lacey Act) in the Little River. The potential conveyance of an invasive, non-native species across state boundaries via pipelines may be subject to federal, commerce, civil, and/or criminal penalties. This strategy does have flexibility to reduce the risk of the conveyance of non-native species across state boundaries should invasive and injurious species be identified in the Little River. A new project configuration forgoing direct transfer to a reservoir and instead delivering the water supply directly to a new water treatment plant may be required. It is anticipated that a 281MGD water treatment plant would satisfy potential mitigation requirements. Coordination with U.S. Fish & Wildlife Service and seeking legislative relief from the Lacey Act should invasive species be identified in the Little River would be expected to pose significant challenges.

Table 7-50. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Contract	Arkansas Natural Resources Commission	Requires an agreement of authorization for Dallas to transport and use the water.
Section 404	USACE	Required for construction activities in waters of the U.S.

7.9.7 Flexibility and Phasing

Development and implementation of this strategy would come with inherent risks related to permitting and environmental impacts since this project would divert 268 MGD of water through a 207-mile-long pipeline.

There is flexibility in the currently identified project delivery location. A different reservoir (or multiple reservoirs) could be identified as the delivery location should DWU subsystem needs arise that could be met through this water supply.

No project partners were identified or considered for this analysis. However, there would be opportunities for partnership with North Texas water providers on this project to reduce project costs.

7.9.8 Equity Impacts

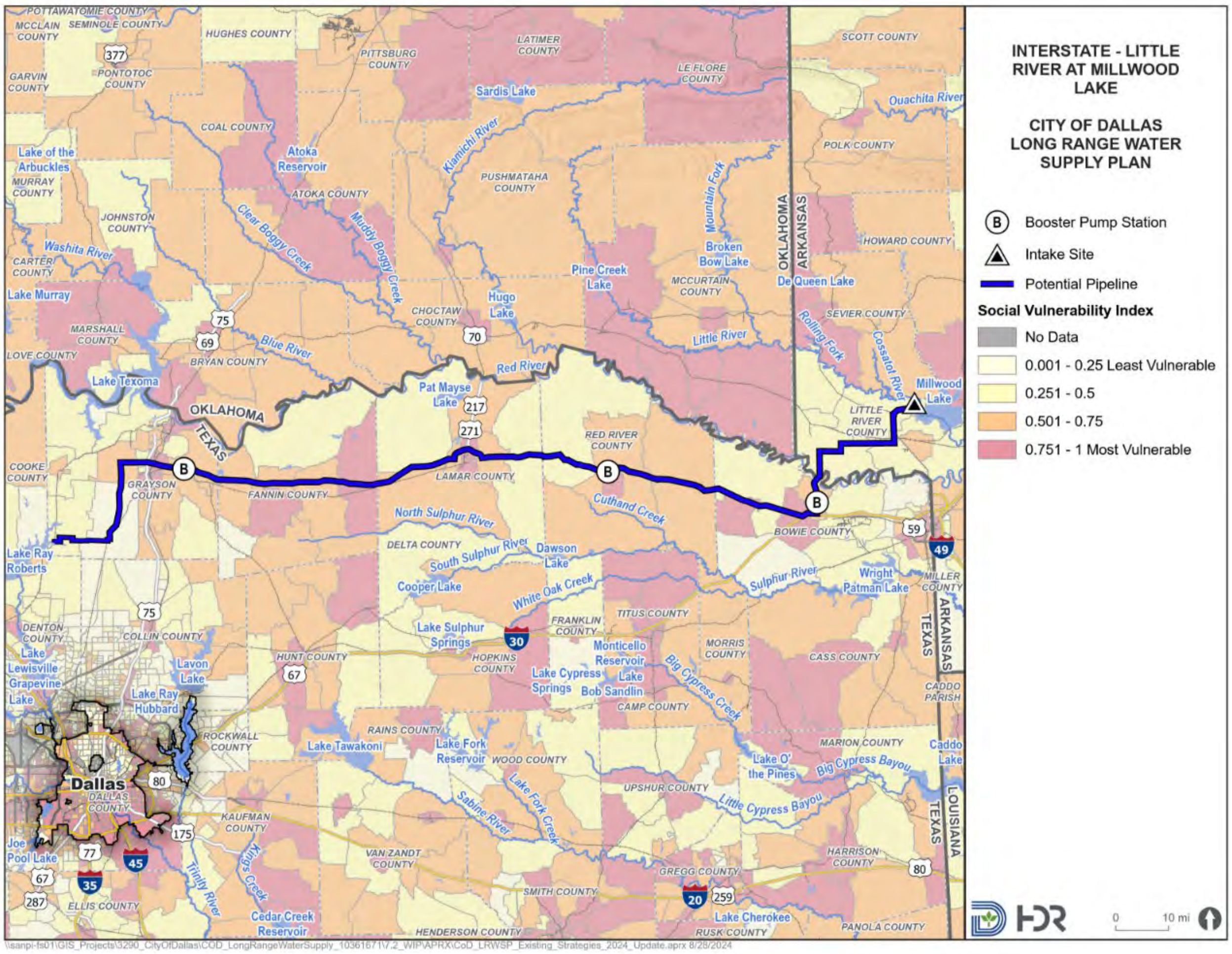
Impacts to equity from implementation of the Little River-Millwood Lake strategy may result from placement of project infrastructure, such as the transmission pipeline, intake pump station, or booster pump stations. A reasonable project alignment was chosen based off preliminary engineering judgment.

Equity was evaluated by looking at the amount of area per quartile that project components are proposed to be located in. The land area required for the pump stations and pipeline were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-51Table 7-23. A visual representation of the quartile distribution is shown in Figure 7-31.

Table 7-51. Interstate – Little River at Millwood Lake AR SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	**2nd quartile**	**3rd quartile**	**4th quartile (high) highly vulnerable**	**Value**
8.4%	38.0%	43.0%	10.6%	**3**

Figure 7-31. Interstate – Little River at Millwood Lake AR Project Footprint with SVI Visual



Based on the results, over half of the project area is projected to reside in areas with an increased vulnerability to equity impacts. Just over half of the project area resides in the 3rd quartile and indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 3 based on the equity criteria scoring guidelines; indicating that this project may have neutral impacts to socially vulnerable communities and is not expected to provide enhancement to said communities.

Mitigation for implementation of this strategy would not be necessary. However, low mitigation efforts would be effective in removing the majority of project burdens from the socially vulnerable communities.

7.9.9 Alternative Arkansas Water Supply

An alternative Arkansas supply option that Dallas could investigate is from the Red River. An agreement and contract between Dallas and the Arkansas Natural Resources Commission would need to be developed, allowing Dallas to divert a portion of Arkansas' allocated Red River supply. For Dallas to divert water in Arkansas from the mainstem of the Red River, it would be from Reach 2, Subbasin 5 of the Red River Compact. Subbasin 5 is subject to downstream minimum flow requirements. Each Signatory State (Texas, Oklahoma, Arkansas, and Louisiana) has rights to 25% of the flow in the Red River in excess of the minimum flow requirement of 3,000 cubic feet per second at the Arkansas-Louisiana Border. Dallas would look to secure a percentage of Arkansas' 25% rights to Red River water.

The Red River at Spring Bank, AR gage is the upstream flow gage closest to the Arkansas-Louisiana border and was evaluated to determine if there is sufficient flow in excess of the 3,000 cubic feet per second requirement and what portion of Arkansas' 25% would Dallas need to contract for to make this strategy comparable to other interstate strategies evaluated. Reviewing daily average flows for the period of 1997 to 2024 indicate that 25% of excess flows would be on average, 3,510,000acft/yr. If Dallas was looking to secure 268 MGD (300,000 acft/yr) from Arkansas per year, that amount would be just 9% of Arkansas' Red River flows. Recent average daily flows from 2023 to 2024 were reviewed and confirmed there would be 268 MGD available for Dallas to contract. It should be noted that both time periods evaluated did have days where there was not excess flow available. With this possibility, Dallas would need to keep in mind that this supply may be interruptible.

A transmission line from the most southeast part of the Arkansas Red River border to Lake Ray Roberts in Dallas would be 132 inches in diameter and 174 miles long. A 281.2 MGD intake and a channel dam would be required. This project would also have three booster pump stations. The total project cost would be an estimated $6.15 billion with a total annual cost of approximately $516,000,000. The unit cost of water would be $1,720 per acft or $5.28 per 1,000 gallons.

Similar permitting challenges and environmental impacts as discussed previously should be expected. Further evaluation on the potential feasibility of this alignment should be conducted.

7.9.10 References

Arkansas Natural Resources Commission. (2014, November 24). *Arkansas Water Plan Update 2014.* Retrieved from Arkansas Water Plan: https://www.arwaterplan.arkansas.gov/plan/ArkansasWaterPlan/2014AWPWaterPlan/App%20C_Water%20Availability%20Report_Final_11.24.14.pdf

Brown & Root, Inc. (1991, July). *Yield Study Toledo Bend Reservoir.* Retrieved from Texas Water Development Board: https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/90483770.pdf

Emergent Method. (2018, November 30). *Water Resources Final Commission Final Report.* Retrieved from Louisiana Department of Natural Resources: https://www.dnr.louisiana.gov/assets/OC/env_div/gw_res/WRC_Final_Report_113018.pdf

Environmental Protection Agency. (2020). *Little River-Millwood Lake Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Proection Agency: https://mywaterway.epa.gov/waterbody-report/ARDEQH2O/AR_11140109_4020/2020

Environmental Protection Agency. (2022). *Kiamichi River Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/OKDEQ/OK410300010010_00/2022

Environmental Protection Agency. (2024). *Toledo Bend Reservoir Waterbody Report*. Retrieved July 2015, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/LADEQWPD/LA110101_00

HDR and Buhman Associates, LLC. (2010). *Evaluation of Water Supply Alternatives for the Kiamichi River, Cache Creek, and Beaver Creek.* unpublished by may be obtainable from TRWD.

Oklahoma Water Resources Board. (2011, October). *2012 Oklahoma Comprehensive Water Plan.* Retrieved from Oklahoma Water Resources Board: https://oklahoma.gov/content/dam/ok/en/owrb/documents/water-planning/ocwp/southeast-planning-region-report.pdf

Oklahoma Water Resources Board. (2024). *Water use Permits in Oklahoma*. (ArcGIS) Retrieved June 10, 2024, from Oklahoma Water Resources Board: https://owrb.maps.arcgis.com/apps/dashboards/6e5e1ce9c3a640b3a484e430d4db8139

US Army Corps of Engineers. (2022). *Millwood Lake Master Plan Shoreline Management Plan Revision*. Retrieved from US Army Corps of Engineers: https://www.swl.usace.army.mil/Missions/Planning/Millwood-Lake-Master-Plan-Revision/Documents/

USGS. (2024, September 2024). *NAS - Nonindegenous Aquatic Species*. Retrieved September 4, 2024, from USGS: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=5

7.10 Toledo Bend Reservoir to Dallas West System

The Toledo Bend Reservoir to the Dallas West System is a regional project and was designated as an alternative in the 2014 LRWSP. After reevaluation, this strategy has been designated as an alternative again in the 2024 LRWSP.

In the 1960s, the Sabine River Authority of Texas (SRA Texas) and the Sabine River Authority of Louisiana (SRA Louisiana) constructed the Toledo Bend Reservoir (Toledo Bend) on the Texas-Louisiana border. The reservoir has a conservation capacity of 4.477 million acft and has a yield of approximately 1.5 million acft/yr. SRA Texas holds a Texas water right to divert 670 MGD (750,000 acft/yr) from Toledo Bend. Up to 312 MGD (350,000[57] acft/yr) is being considered for transport as part of Phase 1 of this two-phase strategy, from Toledo Bend to other lakes in Texas.

7.10.1 Strategy Description

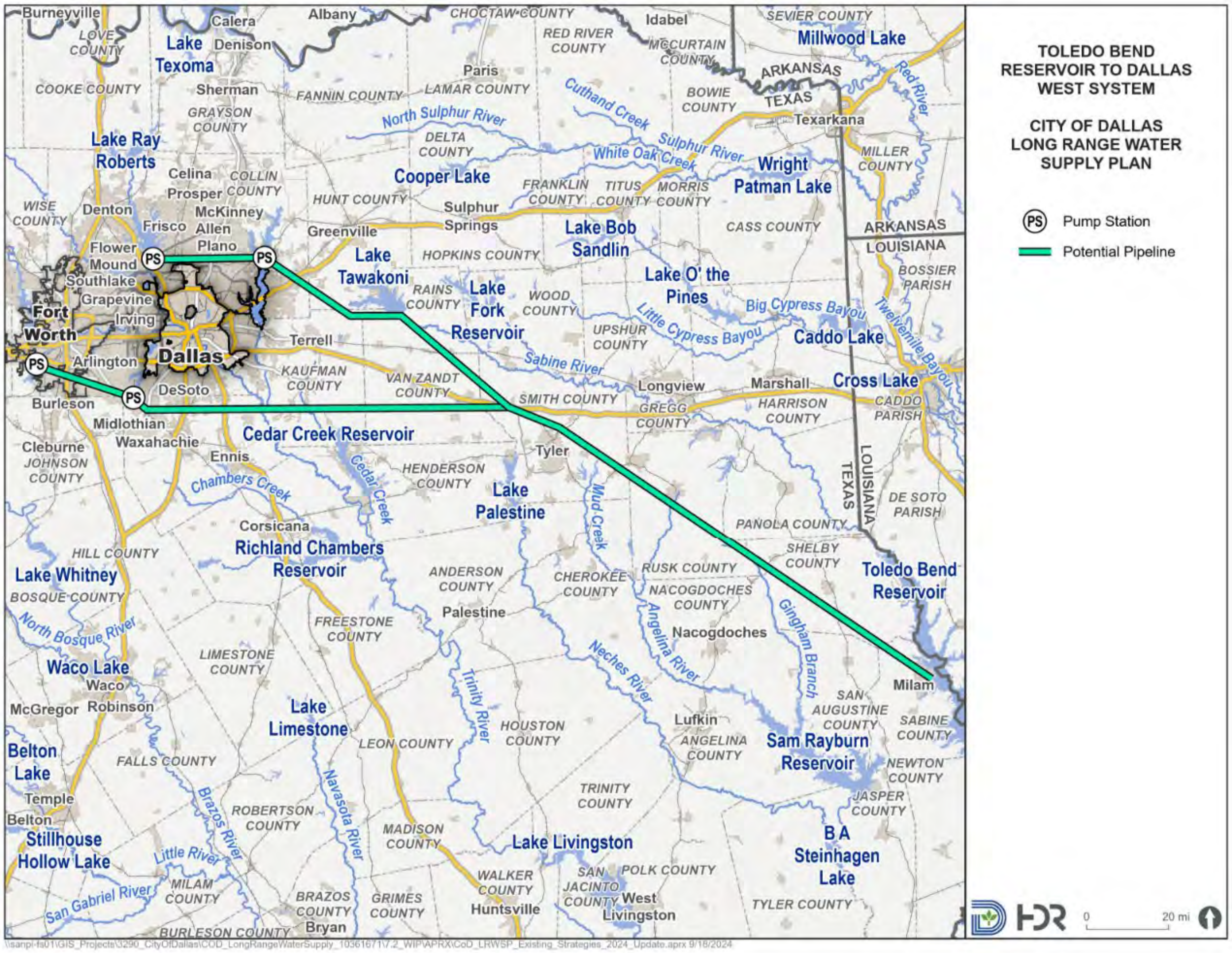
Dallas, TRWD, NTMWD, and UTRWD have been collaborating for many years on a potential transfer of water from Toledo Bend to the upper Sabine River basin and to the Dallas-Fort Worth (DFW) Metroplex. The most recent project details regarding the potential transfer can be found in the 2021 Region C Water Plan. The transfer of water from Toledo Bend was split into two phases, both phases transferring 312 MGD to the project partners for a total future delivery amount of 624 MGD. The first phase was included in the 2021 RWP while the second phase was not. Phase 1 was the only phase of the project included in the 2024 LRWSP strategy evaluation. The Phase 1 supply volume of 312 MGD (350,000 acft/yr) is assumed to be divided between the project partners as follows:

- Dallas Water Utilities – 89 MGD (100,000 acft/yr or 28.6%)
- NTMWD – 89 MGD (100,000 acft/yr or 28.6%)
- TRWD – 89 MGD (100,000 acft/yr or 28.6%)
- UTRWD – 45 MGD (50,000 acft/yr or 14.2%)

A shared pipeline over 200 miles long would be needed to deliver supplies between the reservoir and Dallas with deliveries to Dallas assumed to be to the Joe Pool Lake or Lewisville Lake area (Figure 7-32).

[57] 2021 Region C Water Plan

Figure 7-32.Toledo Bend Reservoir to Dallas West System



7.10.2 Water Availability

Up to 312 MGD (350,000 acft/yr) is being considered for transport to Dallas and other entities in the DFW Metroplex as Phase 1 of the Toledo Bend project. Phase 1 of this project would provide 89 MGD (100,000 acft/yr) to Dallas. SRA Texas currently holds a Texas water right permit to divert 670 MGD (750,000 acft/yr) from Toledo Bend and is seeking the right to divert an additional 261 MGD (293,000 acft/yr). An additional 312 MGD would be provided to Dallas and other entities through Phase 2.

7.10.3 Project Cost Estimate

The total project costs for this estimate are taken from the Toledo Bend Strategy contained in the 2021 Region C RWP and were modified to September 2023 dollars for use in the 2024 Dallas LRWSP. Shared project facilities will include an intake and pump station at Toledo Bend Reservoir, over 200 miles of transmission pipeline, and booster pump stations. The system is sized for a 1.5 peaking factor.

A summary of the total project costs of the project for the Toledo Bend pipeline is listed in Table 7-52 for both the entire project and Dallas' portion. Dallas' portion of the total project costs are $2.45 billion. Annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and Dallas' portion is estimated to be $211,038,000per year. The raw water purchase cost from SRA Texas would need to be negotiated as part of project implementation, and therefore not included in this cost estimate[58]. The purchase cost of water is also excluded to provide a similar comparison with other strategies without negotiated rates. This value would need to be negotiated between Dallas and SRA as part of project implementation. The unit cost of water for this project is $2,110 per acft or $6.48 per 1,000 gallons. After debt service, the unit cost of water would decrease to $386 per acft or $1.19 per 1,000 gallons. The unit cost is based on the assumed 100,000 acft of water available for purchase and excludes the raw water purchase cost.

[58] The SRA Texas purchase cost of raw water is set by the SRA Board.

Table 7-52. Cost Estimate Summary for Dallas' Share of Toledo Bend Reservoir, Phase 1

Table units: September 2023 Dollars

Item	Estimated Cost of Facilities	Estimated Portion of Dallas' Cost of Facilities
CAPITAL COST		
Intake and Pump Stations	$657,325,000	$140,013,000
Transmission Pipeline	$4,865,662,000	$1,421,340,000
Transmission Pump Station(s) & Storage Tank(s)	$507,950,000	$179,432,000
TOTAL COST OF FACILITIES	**$6,030,937,000**	**$1,740,785,000**
OTHER PROJECT COSTS		
Engineering		
- Planning (3%)	$180,928,000	$52,224,000
- Design (7%)	$422,166,000	$121,855,000
- Construction Engineering (1%)	$60,309,000	$17,408,000
Legal Assistance (2%)	$120,619,000	$34,816,000
Fiscal Services (2%)	$120,619,000	$34,816,000
Pipeline Contingency (15%)	$729,849,000	$213,201,000
All Other Facilities Contingency (20%)	$233,055,000	$63,889,000
Environmental & Archaeology Studies and Mitigation	$23,371,000	$6,029,000
Land Acquisition and Surveying	$74,833,000	$15,556,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$519,785,000	$149,538,000
TOTAL COST OF PROJECT	**$8,516,471,000**	**$2,450,117,000**
ANNUAL COST		
Debt Service (3.5 percent, 20 years)	$599,228,000	$172,393,000
Operation and Maintenance		
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$48,657,000	$14,213,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$29,132,000	$7,986,000
Pumping Energy Costs (0.09 $/kW-hr)	$58,257,000	$16,446,000
TOTAL ANNUAL COST	**$735,274,000**	**$211,038,000**
Available Project Yield (acft/yr)	**350,000**	**100,000**
Annual Cost of Water ($ per acft)	**$2,110**	**$2,110**
Annual Cost of Water ($ per 1,000 gallons)	**$6.48**	**$6.48**
Annual Cost of Water after Debt Service ($ per acft)	**$386**	**$386**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$1.19**	**$1.19**

Source: http://www.twdb.texas.gov/waterplanning/rwp/plans/2021/CRegion_C_2021_RWPV1.pdf

7.10.4 Water Quality

Water quality of Toledo Bend Reservoir was evaluated with no drinking water impairments identified. Fish and wildlife impairments were noted due to the identification of mercury in fish tissue, however, this designation is not expected to impact water treatment.

7.10.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database and IPaC[59]; TPWD, TXNDD[60] and species county lists[61]; and the USGS NHD[62]. Table 7-53 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of desktop environmental factors; further desktop and field studies would be needed in any feasibility or permitting effort to address these potential concerns with the respective regulatory agencies.

Since the reservoir is an existing source of water, impacts to the environment are limited to the pipeline route, environmental flows downstream of Toledo Bend and transmission facilities to the various water bodies.

7.10.5.1 HABITAT

The proposed pipeline occurs within a variety of land classifications including pasture, urban, herbaceous, forested, and wetland land types. The proposed pipeline route will cross sections of the Sabine National Forest, three TPWD designated ecologically significant stream segments, and environmentally sensitive bottomland hardwoods and riparian areas. The pipeline route crosses portions of thirteen counties which include numerous state- and federally listed endangered or threatened species, and federal candidate species that use these various habitats. However, specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to these geographically limited environmental sites resulting in medium to low impacts. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities will help to minimize potential impacts to the discussed sensitive natural areas.

7.10.5.2 ENVIRONMENTAL WATER NEEDS

No flow would be diverted from tributaries to the Toledo Bend Reservoir which could contain sensitive habitat. Therefore, no impacts are anticipated to water availability for

---

[59] US Fish and Wildlife Service. (2024). *Information for Planning and Consulting (IPAC)*. Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[60] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[61] Texas Parks and Wildlife Department. (2024). *Rare, Threatened, and Endangered Species of Texas (RTEST)*. Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[62] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

riparian and aquatic habitat in the area. Implementation and operation of this strategy will require an amendment to the TCEQ water rights permit to include an interbasin transfer authorization allowing water to be used in the Trinity River Basin, which could subject the permit to TCEQ environmental flow standards.

7.10.5.3 BAYS AND ESTUARIES

Transporting of supplies out of the basin will impact flows to Sabine Lake and its estuary downstream of Toledo Bend. Freshwater stream flows are critical to the health of the Sabine estuary system. Sabine Lake and its estuary downstream experience an average annual flow of approximately 4.5 million acft/yr. The Toledo Bend Reservoir to Dallas West System would divert 350,000 acft/yr, or approximately 8 percent of downstream average annual flow. A medium effect is anticipated to freshwater inflow to Lake Sabine and its estuary. The additional 293,000 acft/yr (7% of average annual flow) that SRA Texas is seeking the right to divert would require further evaluation for specific impacts to Sabine Lake and its estuary.

7.10.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-53 represent all species federally or state listed as threatened or endangered, and federal candidate and proposed species in the counties for which the project will be located. The project area includes 35 species that meet these criteria. These species would need to be considered through the design process and could potentially require mitigation measures during project permitting and implementation. In addition, the project area has USFWS designated critical habitat areas for the threatened Neches River rose-mallow, endangered Texas golden gladecress, proposed threatened Louisiana pigtoe, and proposed endangered Texas heelsplitter (IPaC). Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.10.5.5 WETLANDS

The proposed pipeline intersects approximately 350 NHD streams, rivers, and creeks including the Angelina River, Attoyac River, Neches River, Trinity River, and numerous creeks, bayous, and tributaries. Although approximately 110 acres of NWI-mapped wetlands occur along the proposed pipeline corridor, flexibility in the pipeline placement would be used to minimize or avoid potential impacts to the majority of these areas.

7.10.5.6 AGRICULTURAL AND NATURAL RESOURCES

Construction activities associated with the project transmission pipeline will impact an estimated 438 acres of soils identified by the USDA as prime farmland soils within 13 counties. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because these areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above.

Table 7-53. Environmental Factors for the Toledo Bend Reservoir Project

Environmental Factors	Comment(s)
Habitat	Medium Impact
Environmental Water Needs	Interbasin transfer could open up the permit to new TCEQ environmental flow standards. Low Impact
Bays and Estuaries	Medium Impact
Threatened and Endangered Species	Bachman's sparrow (ST), black rail (FT, ST), golden-cheeked warbler (FE, SE), piping plover (FT, ST), red-cockaded woodpecker (FE, SE), rufa red knot (FT, ST), swallow-tailed kite (ST), white-faced ibis (ST), whooping crane (FE, SE), wood stork (ST), paddlefish (ST), western creek chubsucker (ST), monarch butterfly (C), black bear (ST), Louisiana black bear (ST), Rafinesque's big-eared bat (ST), tricolored bat (FPE), Brazos heelsplitter (ST), Louisiana pigtoe (FPT, ST), sandbank pocketbook (ST), southern hickorynut (ST), Texas fawnsfoot (FPT, ST), Texas heelsplitter (ST), Texas pigtoe (ST), Trinity pigtoe (ST), earth fruit (FT, ST), Neches River rose-mallow (FT, ST), small-headed pipewort (ST), Texas golden gladecress (FE, SE), white bladderpod (FE, SE), alligator snapping turtle (FPT, ST), Brazos water snake (ST), Louisiana pine snake (FT, ST), northern scarlet snake (ST), Texas horned lizard (ST). The pipeline crosses potential critical habitat for two federally listed threatened/endangered species and two federally proposed threatened/endangered species. High Impact
Wetlands	Low to Medium Impact
Agricultural and Natural Resources	Temporary impacts to 438 acres of USDA prime farmland soils. Low impact

Source: USFWS, 2024 and TPWD 2024

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.

ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

7.10.6 Confidence and Permitting

The Toledo Bend Reservoir project would pose several permitting challenges along with the typical challenges associated with a new project, summarized in Table 7-54. Water supply from Toledo Bend will require a contract with the SRA Texas, who may need to secure additional water from Louisiana's allocation or may need to permit additional water from the unallocated portion of the Reservoir.

The water rights permit will need to be amended to include an interbasin transfer authorization to allow the water to be used in the Trinity River Basin. An amendment to the permit could potentially subject the existing water right to Texas environmental flow standards. A Section 404 permit from the USACE for impacts to a waters of the U.S. from construction activities would likely be needed for the construction of the proposed project.

Table 7-54. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit Amendment	TCEQ	Requires an inter-basin transfer authorization for Dallas to transport and use the water in the Trinity River Basin.
Section 404	USACE	Required for construction activities in waters of the U.S.

7.10.7 Flexibility and Phasing

Toledo Bend Reservoir is a significant project that has been separated into two phases to increase feasibility of the project and deliver water supply sooner to the project partners. Implementation of this strategy would likely take 15 to 20 years due to the size of the project and current conceptual status.

Toledo Bend Reservoir is considered a reliable source of water however, there are inherent risks related to performance, permitting, and competition. The risks are regarding other entities in Southeastern Texas seeking water from SRA Texas which could reduce Dallas', NTMWD's, TRWD's, and UTRWD's proposed portion of supply, unless SRA Texas can secure additional water. SRA Texas is seeking the right to divert an additional 293,000 acft/yr from TCEQ. Without sufficient supply, Phase 2 of the project could become infeasible This project has some variation in configuration with one intake and a delivery pipeline that diverges into two delivery routes near the DFW Metroplex. Dallas could use this variation to receive the water either through Joe Pool Lake or Lake Lewisville depending on DWU's system availabilities and needs. There is limited flexibility outside of the two delivery routes since water will be delivered to three other water providers as well.

The project partners have been evaluating this project for many years and have adjusted the strategy as needed. It is not anticipated that Dallas would receive more than 28.6% of the project supply at this time due to the consideration that there are other major water providers also involved with this project.

7.10.8 Equity Impacts

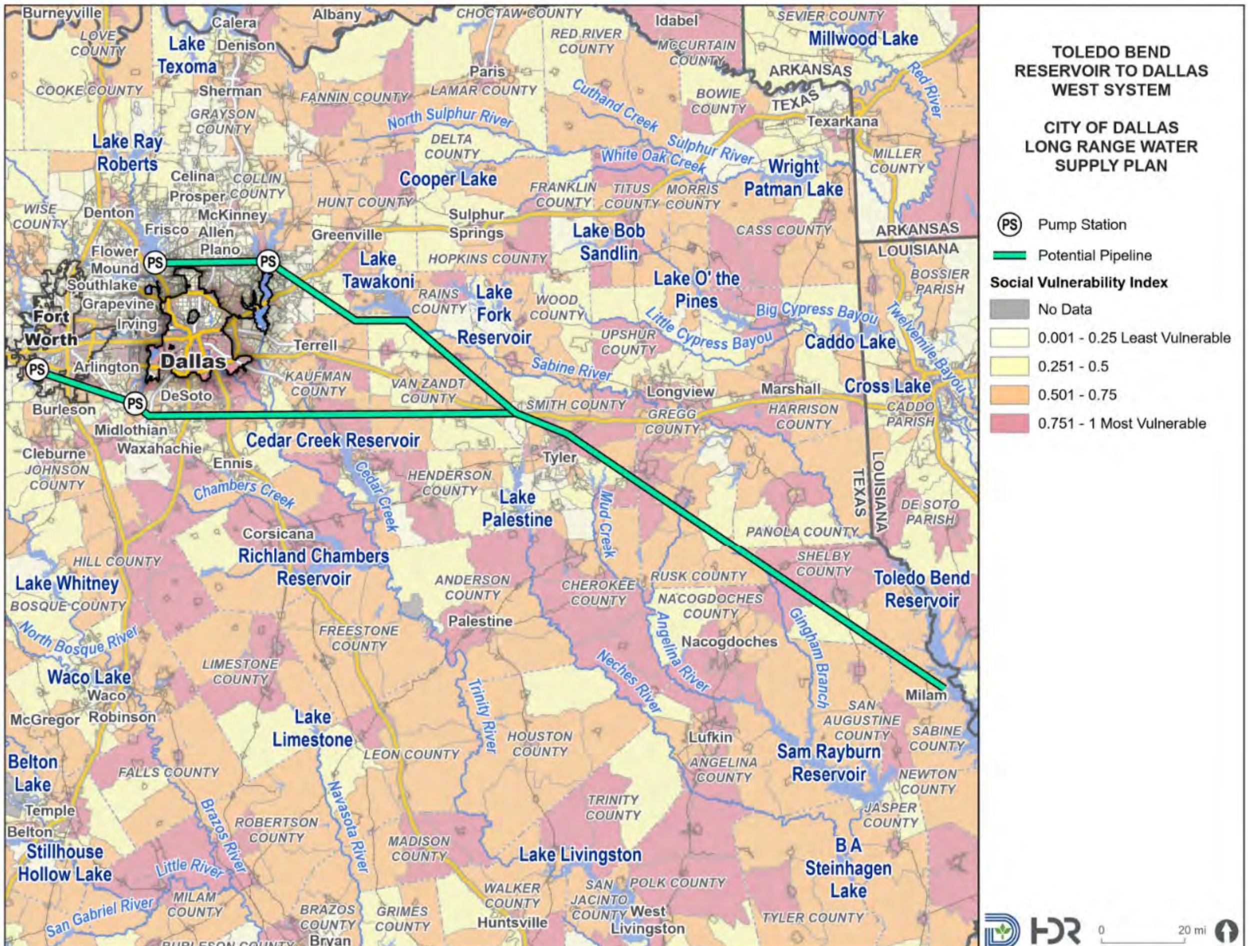
Impacts to equity from implementation of the Toledo Bend Reservoir strategy may result from development of the transmission pipeline and booster pump stations.

Equity was evaluated by looking at the amount of area per quartile where project components are proposed to be located. The land area required for the pipeline and booster pump stations were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-55. A visual representation of the quartile distribution is shown in Figure 7-27.

Table 7-55. Toledo Bend Reservoir SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
6.3%	20.2%	56.4%	17.0%	**2**

Figure 7-33. Toledo Bend Reservoir Project Footprint with SVI Visual



Based on the results, over half of the project area is projected to reside in areas with an increased vulnerability to equity impacts. The large distribution of project area residing in the 3rd quartile indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 2 based on the equity criteria scoring.

The scoring and quartile distribution indicates that this project may have some negative impacts to socially vulnerable communities and may slightly increase inequity to said communities. Moderate mitigation for implementation of this strategy would be necessary to reduce the burden on socially vulnerable communities.

7.10.9 References

Freese and Nichols, Inc.; Plummer Associates, Inc.; CP&Y, Inc.; and Cooksey Communications, Inc. 2020. “Volume 1. Main Report.” 2021 Region C Water Plan. Prepared for the Region C Water Planning Group. http://www.twdb.texas.gov/waterplanning/rwp/plans/2021/CRegion_C_2021_RWPV1.pdf

Schaumburg and Polk, Inc.; Freese and Nichols, Inc.; and Alan Plummer Associates, Inc. 2009. “East Texas Region, Special Study No. 1: Inter-Regional Coordination on the Toledo Bend Project.” Final Report. Prepared for East Texas Regional Water Planning Group. http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0704830694_RegionI/Special%20StudyNo1.pdf

7.11 Interstate - Toledo Bend SRA LA

This is an interstate strategy that evaluates the diversion of a large supply of water from an entity in Louisiana. Toledo Bend Reservoir SRA LA is a new strategy evaluated in the 2024 LRWSP and has been designated as an alternative strategy.

In the 1960s, the Sabine River Authority of Texas (SRA Texas) and the Sabine River Authority of Louisiana (SRA Louisiana) constructed Toledo Bend Reservoir (Toledo Bend) on the Texas-Louisiana border. The reservoir has a conservation capacity of 4,477,000 acre-feet. The firm yield of Toledo Bend reservoir is 2,086,600 acre-feet per year. SRA Louisiana and SRA Texas each hold a water right from their respective states to divert 670 MGD (750,000 acft/yr) from Toledo Bend.

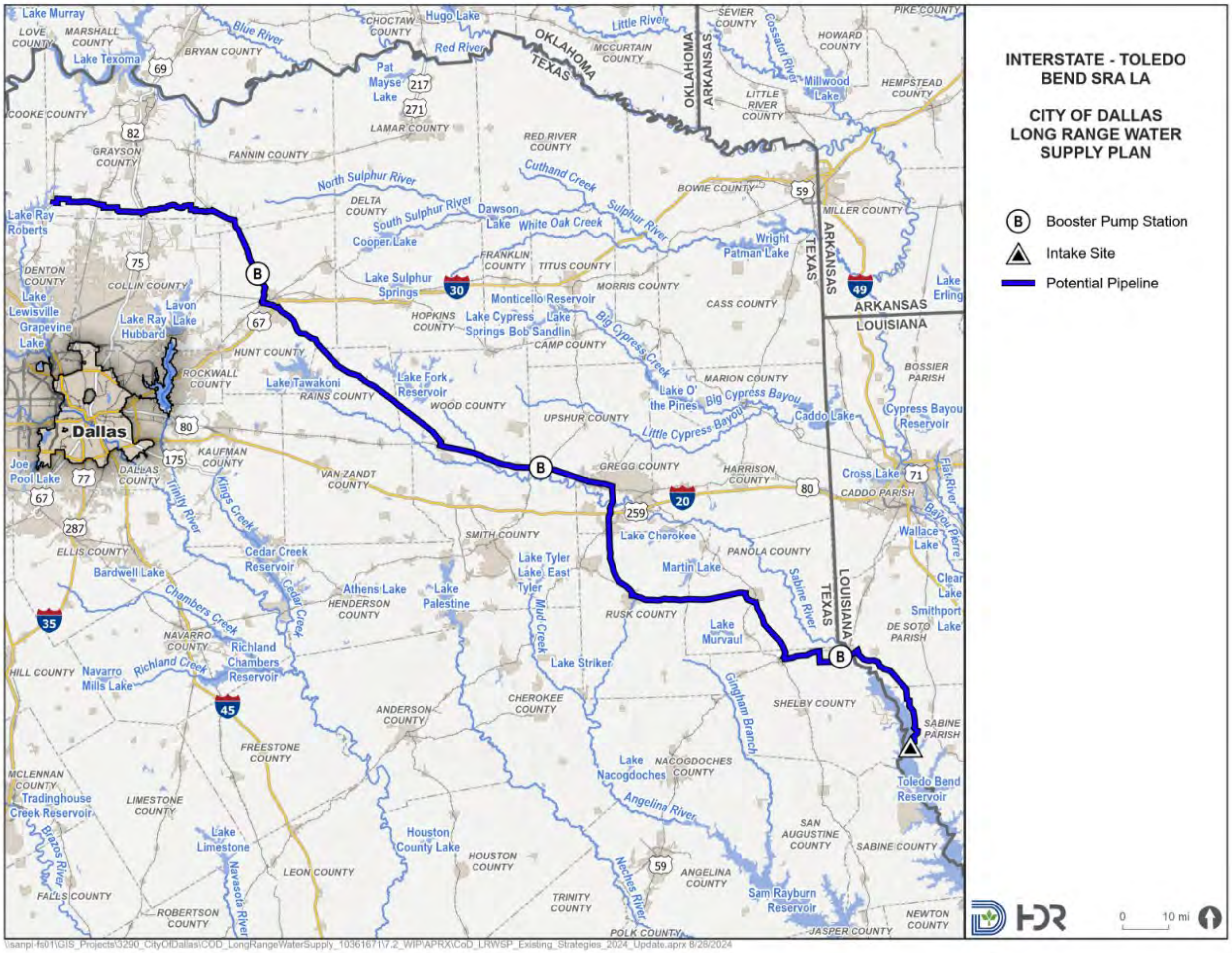
7.11.1 Strategy Description

For this evaluation of Toledo Bend Reservoir as an interstate strategy, a water supply contract with SRA Louisiana and no additional partnerships will be considered. For the purpose of this analysis, it is assumed that Dallas could purchase a total of 179 MGD (200,000 acft/yr).

The intake and pump station associated with the project would be located in Louisiana. A 272-mile pipeline would be needed to deliver supplies from Toledo Bend to Dallas at Lake Ray Roberts (Figure 7-34). An outfall structure to reduce residual head at the pipeline outlet at Lake Ray Roberts is also needed.

It is assumed that SRA Louisiana is interested in conducting large water sales to compensate for operating costs and other expenditures related to Toledo Bend Reservoir. The value of hydropower has declined while the costs to maintain and operate the hydroelectric project have increased. SRA Louisiana has been exploring the option of out-of-state water sales and looking into the legalities of it. A water supply contract would be required with SRA Louisiana to secure the source for Dallas.

Figure 7-34. Interstate – Toledo Bend Reservoir SRA LA to Lake Ray Roberts



7.11.2 Water Availability

SRA Louisiana holds a water right permit to divert 670 MGD (750,000 acft/yr) from Toledo Bend Reservoir. Based on an outside evaluation of the out-of-state sale of publicly owned surface water in Louisiana, completed for the State of Louisiana Department of Natural Resources, it was found that based on historical data, Toledo Bend Reservoir would be able to remain in its operational limits with a large water sale (200,000 acft/yr or approximately 10% of the annual yield). For this evaluation it is assumed that no other large water sales have been conducted since the study and there is still 179 MGD (200,000 acft/yr) available for sale without exceeding the operational limits.

7.11.3 Project Cost Estimate

The following facilities are required to deliver water from the Toledo Bend Reservoir to Lake Ray Roberts:

- A 187.4 MGD intake and pump station at Toledo Bend Reservoir

- Approximately 272 miles of 108-inch transmission pipeline from Toledo Bend Reservoir to Lake Ray Roberts.
- Three booster pump stations along the pipeline route: one with 21,836 HP and two with 19,488 HP
- Outfall structure at Lake Ray Roberts

A summary of total project costs of the project for the Toledo Bend Reservoir pipeline is listed in Table 7-56. The total project costs are $7.55 billion. Annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and are estimated to be $623,485,000 per year. The raw water purchase cost from SRA Louisiana would need to be negotiated as part of project implementation, and therefore not included in this cost estimate. The unit cost of water for this project is $3,117 per acft or $9.57 per 1,000 gallons. The unit cost is based on the assumed 200,000 acft of water available for purchase and excludes the raw water purchase cost.

Table 7-56. Cost Estimate Summary for Interstate - Toledo Bend Reservoir SRA LA

Table units: September 2023 Dollars

Item	*Estimated Costs for Facilities*
CAPITAL COSTS	
Intake Pump Stations (187.4 MGD)	$75,062,000
Transmission Pipeline (108 in. dia., 272.4 miles)	$4,951,688,000
Transmission Pump Station(s) & Storage Tank(s)	$214,761,000
Backup Generator & Outfall Structure	$30,011,000
TOTAL COST OF FACILITIES	**$5,271,522,000**
OTHER PROJECT COSTS	
Engineering	
- Planning (3%)	$158,146,000
- Design (7%)	$369,007,000
- Construction Engineering (1%)	$52,715,000
Legal Assistance (2%)	$105,430,000
Fiscal Services (2%)	$105,430,000
Pipeline Contingency (15%)	$742,753,000
All Other Facilities Contingency (20%)	$63,967,000
Environmental & Archaeology Studies and Mitigation	$8,199,000
Land Acquisition and Surveying (3,322 acres)	$4,649,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$668,539,000
TOTAL COST OF PROJECT	**$7,550,357,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$529,492,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$49,817,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$7,246,000
Pumping Energy Costs (0.09 $/kW-hr)	$36,930,000
TOTAL ANNUAL COST	**$623,485,000**
Available Project Yield (acft/yr)	200,000
Annual Cost of Water ($ per acft), based on PF=1.05	$3,117
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.05	$470
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.05	$9.57
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.05	$1.44

7.11.4 Water Quality

Water quality of Toledo Bend Reservoir was evaluated with no drinking water impairments identified. Fish and wildlife impairments were noted due to the identification of mercury in fish tissue, however, this designation is not expected to impact water treatment.

7.11.5 Environmental Impacts

To determine potential environmental issues, a preliminary desktop review of publicly available data was conducted which included USFWS NWI and IPaC databases; TPWD threatened and endangered species lists and TXNDD; Louisiana Department of Wildlife and Fisheries (LDWF) Rare Species and Natural Communities; and the USGS NHD. Table 7-49 below summarizes potential environmental issues for this alignment.

Since the reservoir is an existing source of water, impacts to the environment are limited to the pipeline route, environmental flows downstream of Toledo Bend and transmission facilities to the various water bodies.

7.11.5.1 HABITAT

The pipeline route crosses developed areas (linear transportation, roads and rail), agricultural and riparian areas. The wooded riparian areas that occur along and adjacent to the stream and river crossings are commonly utilized by many different species and should be avoided as much as reasonably possible. The USFWS has identified potential critical habitats for the Texas heelsplitter and the Louisiana pigtoe within the proposed pipeline area. Pipelines generally have sufficient design flexibility to avoid or minimize impacts to existing habitat therefore impacts to habitat are expected to be low.

7.11.5.2 ENVIRONMENTAL WATER NEEDS

No flow would be diverted from tributaries to the Toledo Bend Reservoir which could contain sensitive habitat. Therefore, no impacts are anticipated to water availability for riparian and aquatic habitat in the area. Coordination with the Louisiana Department of Environmental Quality will be required. This diversion would not be subject to a TCEQ interbasin transfer permit since the water supply is outside the state of Texas.

7.11.5.3 BAYS AND ESTUARIES

Transporting of supplies out of the basin will impact flows to Sabine Lake and its estuary downstream of Toledo Bend. Freshwater stream flows are critical to the health of the Sabine estuary system. Sabine Lake and its estuary downstream experience an average annual flow of approximately 4.5 million acft/yr. The Toledo Bend Reservoir SRA LA strategy would divert 200,000 acft/yr, or approximately 4 percent of downstream average annual flow. A medium effect is anticipated to freshwater inflow to Lake Sabine and its estuary.

7.11.5.4 THREATENED AND ENDANGERED SPECIES

The pipeline route traverses potential habitat for 13 listed federal species, 4 Louisiana state listed species, and 27 Texas state listed species. Field reconnaissance surveys and further desktop analysis should be conducted to assess for suitable habitat for the listed and/or proposed species during project development.

According to the USFWS IPaC resource list, the alignment crosses proposed critical habitats for the Texas heelsplitter in Lake Fork Creek at E US Highway 80 and the Louisiana pigtoe in the Sabine River at SH 42N. The City of Dallas should monitor both species for any changes to the status of these species and to their proposed critical habitats.

Due to the significant number of water crossings, the federally threatened Texas fawnsfoot, state threatened Louisiana pigtoe, and federally proposed endangered Texas heelsplitter may present a challenge to the project; however, these species are generally only found in the larger to medium sized flowing streams with mud, sand, and gravel substrate and are intolerant of impoundment. With proper design, and BMPs, impacts to in stream habitat, riparian habitat, and water quality can be avoided or minimized. The wooded riparian areas that occur along and adjacent to the stream and river crossings may be considered suitable habitat for the endangered northern long-eared bat or the proposed endangered tricolored bat. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

These species would need to be considered through the design process and could potentially require coordination with state or federal agencies, or mitigation measures during and/or after the project. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities will minimize impacts to listed species. Trenchless construction may reduce potential impacts to mussel species listed above.

7.11.5.5 WETLANDS

Based on a high-level desktop review, the proposed intake, outfall, and booster pump station occur at jurisdictional waters, and the pipeline and crosses approximately 300 named and unnamed water features. Streams and creeks would be crossed perpendicularly, avoiding environmentally sensitive areas where feasible. Approximately 90 acres of NWI wetlands occur within a 50-foot buffer of the proposed pipeline corridor. Wetlands need to be further delineated and confirmed in the field to quantify any impacts to jurisdictional features, however, impacts to wetlands associated with this project are anticipated to be low. It would be recommended that efforts be made during the design process to avoid impacts to potential Waters of the United States (WOTUS) where possible. Trenchless construction may reduce potential impacts to WOTUS.

7.11.5.6 AGRICULTURAL AND NATURAL RESOURCES

Within a 50-foot buffer of the pipeline, Toledo Bend to Lake Ray Roberts would temporarily or permanently impact an estimated 143 acres of soils identified by the USDA as prime farmland soils in Texas[63]. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction of the underground pipeline is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Issues section above.

Table 7-57. Environmental Factors for the Interstate – Toledo Bend Reservoir SRA LA Project

Environmental Factors	Comment(s)
Habitat	Largely developed linear transportation (roads, rail) urban areas except for riparian areas at creek crossings. Low Impact
Environmental Water Needs	Low Impact
Bays and Estuaries	Medium Impact
Threatened and Endangered Species	northern long-eared bat (FE), tricolored bat (FPE), piping plover (LT ST), red-cockaded woodpecker* (LE SE), rufa red knot (LT ST), whooping crane (LE SE), alligator snapping turtle (FPT), Louisiana pigtoe (FPT ST), Texas fawnsfoot (LT), Texas heelspliter (PE ST), monarch butterfly (C), Neches River rose-mallow (LT), Texas prairie dawn-flower (LE), white-faced ibis (ST), wood stork (ST), swallow-tailed kite (ST), black rail (ST), Bachman's sparrow (ST), shovelnose sturgeon (ST), paddlefish (ST), chub shiner (ST), blue sucker (ST), Western Creek chubsucker (ST), Rafinesque's big-eared bat (ST), black bear (ST), Louisiana black bear (ST), alligator snapping turtle (ST), Texas horned lizard (ST), northern scarlet snake (ST), Louisiana pine snake* (ST), sandbank pocketbook, southern hickorynut (ST), earth fruit* (ST) The alignment crosses federally proposed critical habitats for the Texas heelsplitter (*Potamilus amphichaenus)* in Lake Fork Creek at E US Highway 80, and federally proposed critical habitat Louisiana pigtoe (*Pleurobema riddelli)* in the Sabine River at State Highway (SH) 42N. High Impact
Wetlands	Low to Medium Impact
Agricultural and Natural Resources	Temporary impacts to 143 acres of USDA prime farmland soils. Low impact

Source: USFWS, 2024 and TPWD 2024

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.

ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

[63] Farmland soil data insufficient to make a determination in Louisiana.

7.11.6 Confidence and Permitting

The Toledo Bend Pipeline project would pose several permitting challenges. Water supply from Toledo Bend will require a contract with SRA Louisiana. A Section 404 permit from the USACE for impacts would be needed for impacts of the intake, diversion facility, pipelines, or outfalls if they occur below the OHWM of a jurisdictional water. It is anticipated that the USACE Fort Worth District would be the lead agency.

Other aspects of permitting and implementation to consider are the Sabine River Compact, which maintains the equitable apportionment of waters of the Sabine River between Texas and Louisiana, and the Federal Energy Regulatory Commission (FERC) which provides the licensing agreement in which Toledo Bend is operated in accordance with.

An interstate water agreement will pose some degree of implementation issues as Louisiana has limited experience with out-of-state water sales. The state of Louisiana and SRA Louisiana have been discussing out-of-state water sales but a water supply agreement between DWU and SRA Louisiana would likely be one of the first.

An agreement between DWU and both SRA Louisiana and SRA Texas may reduce implementation issues and could allow for a larger volume of water to be purchased but has not been evaluated.

Potential risk associated with this strategy is the Lacey Act. The Lacey Act may inhibit this strategy should there be identification of an invasive or “injurious species” (as defined by the Lacey Act) in the Toledo Bend Reservoir. The potential conveyance of an invasive, non-native species across state boundaries via pipelines may be subject to federal, commerce, civil, and/or criminal penalties. This strategy does have flexibility to reduce the risk of the conveyance of non-native species across state boundaries should invasive and injurious species be identified in Toledo Bend Reservoir. A new project configuration forgoing direct transfer to a reservoir and instead delivering the water supply directly to a new water treatment plant may be required. It is anticipated that a 187 MGD water treatment plant would satisfy potential mitigation requirements. Coordination with U.S. Fish & Wildlife Service and seeking legislative relief from the Lacey Act should invasive species be identified in the Toledo Bend Reservoir would be expected to pose significant challenges.

Table 7-58. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Contract	SRA Louisiana	Requires an agreement of authorization for Dallas to transport and use the water.
Section 404	USACE	Required for construction activities in waters of the U.S.

7.11.7 Flexibility and Phasing

There is flexibility in the currently identified project delivery location. A different reservoir (or multiple reservoirs) could be identified as the delivery location should DWU subsystem needs arise that could be met through this water supply.

No project partners were identified or considered for this analysis. However, there would be opportunities for regional partnership on this project to reduce project costs. Should Dallas agree to sharing water volumes and project costs with another water provider, it is likely that a larger volume of water would need to be secured from SRA LA so this project is still beneficial to Dallas and make it more economically feasible to secure water from an out-of-state source.

7.11.8 Equity Impacts

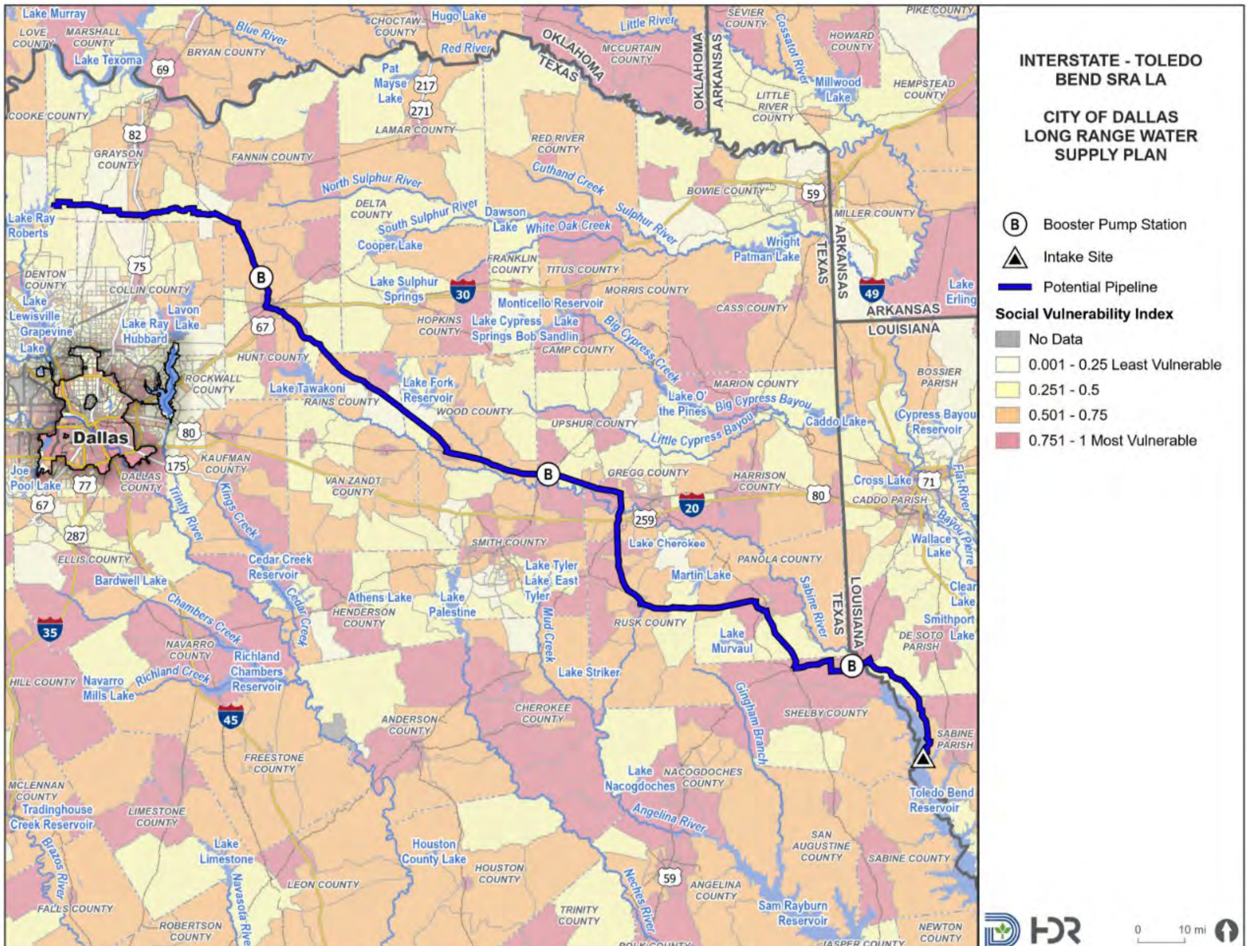
Impacts to equity from implementation of the Toledo Bend Reservoir strategy may result from placement of project infrastructure, such as the transmission pipeline, intake pump station, or booster pump stations. A reasonable project alignment was chosen based off preliminary engineering judgment.

Equity was evaluated by looking at the amount of area per quartile that project components are proposed to be located in. The land area required for the pump stations and pipeline were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-59Table 7-23. A visual representation of the quartile distribution is shown in Figure 7-35.

Table 7-59. Interstate – Toledo Bend Reservoir SRA LA SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
12.9%	22.8%	35.5%	28.8%	**2**

Figure 7-35. Interstate – Toledo Bend Reservoir SRA LA Project Footprint with SVI Visual



Based on the results, over half of the project area is projected to reside in areas with an increased vulnerability to equity impacts. The large distribution of project area residing in the 3rd and 4th quartile indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 2 based on the equity criteria scoring guidelines; indicating that this project may have negative impacts to socially vulnerable communities and may slightly increase inequity to said communities.

Moderate mitigation efforts would be needed to reduce the burden of the project on socially vulnerable communities.

7.11.9 Interstate – Toledo Bend Reservoir SRA LA – Texas intake

This strategy currently assumes that since DWU would be contracting with SRA Louisiana, the project intake and pump station on Toledo Bend Reservoir would need to be located within the Louisiana state border. Should this assumption be incorrect and DWU would be allowed to divert contracted water from SRA Louisiana on the Texas side of Toledo Bend reservoir, project costs could be reduced.

By diverting from the Texas side of Toledo Bend Reservoir, almost 20 miles of pipeline could be saved by not having to route a pipeline around Toledo Bend Reservoir and across the Sabine River. A shorter transmission pipeline reduces facilities costs by over 100 million dollars. With a shorter pipeline, there are also approximately 200 less acres that would need to be surveyed and acquired. With contingency costs and interest being reduced, there would be a total project cost savings of about 169 million dollars. The total annual costs would be reduced by 15 million dollars and the unit cost would be reduced from $3,117 per acre-ft to $3,042 per acre-ft or $9.57 per 1,000 gallons to $9.34 per 1,000 gallons.

It should be noted that by diverting from the Texas side of Toledo Bend Reservoir, there may be additional environmental impacts not previously mentioned in the above evaluation. There could be additional wetlands and threatened or endangered species that may be encountered that require additional mitigation. Additionally, depending on the final intake location, pipeline routing may be necessary to avoid impacts to the Sabine National Forest.

Further evaluation on the potential feasibility of this alignment should be conducted.

7.11.10 References

Arkansas Natural Resources Commission. (2014, November 24). *Arkansas Water Plan Update 2014.* Retrieved from Arkansas Water Plan: https://www.arwaterplan.arkansas.gov/plan/ArkansasWaterPlan/2014AWPWaterPlan/App%20C_Water%20Availability%20Report_Final_11.24.14.pdf

Brown & Root, Inc. (1991, July). *Yield Study Toledo Bend Reservoir.* Retrieved from Texas Water Development Board: https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/90483770.pdf

Emergent Method. (2018, November 30). *Water Resources Final Commission Final Report.* Retrieved from Louisiana Department of Natural Resources: https://www.dnr.louisiana.gov/assets/OC/env_div/gw_res/WRC_Final_Report_113018.pdf

Environmental Protection Agency. (2020). *Little River-Millwood Lake Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Proection Agency: https://mywaterway.epa.gov/waterbody-report/ARDEQH2O/AR_11140109_4020/2020

Environmental Protection Agency. (2022). *Kiamichi River Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/OKDEQ/OK410300010010_00/2022

Environmental Protection Agency. (2024). *Toledo Bend Reservoir Waterbody Report*. Retrieved July 2015, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/LADEQWPD/LA110101_00

HDR and Buhman Associates, LLC. (2010). *Evaluation of Water Supply Alternatives for the Kiamichi River, Cache Creek, and Beaver Creek.* unpublished by may be obtainable from TRWD.

Oklahoma Water Resources Board. (2011, October). *2012 Oklahoma Comprehensive Water Plan.* Retrieved from Oklahoma Water Resources Board: https://oklahoma.gov/content/dam/ok/en/owrb/documents/water-planning/ocwp/southeast-planning-region-report.pdf

Oklahoma Water Resources Board. (2024). *Water use Permits in Oklahoma*. (ArcGIS) Retrieved June 10, 2024, from Oklahoma Water Resources Board: https://owrb.maps.arcgis.com/apps/dashboards/6e5e1ce9c3a640b3a484e430d4db8139

US Army Corps of Engineers. (2022). *Millwood Lake Master Plan Shoreline Management Plan Revision*. Retrieved from US Army Corps of Engineers: https://www.swl.usace.army.mil/Missions/Planning/Millwood-Lake-Master-Plan-Revision/Documents/

USGS. (2024, September 2024). *NAS - Nonindegenous Aquatic Species*. Retrieved September 4, 2024, from USGS: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=5

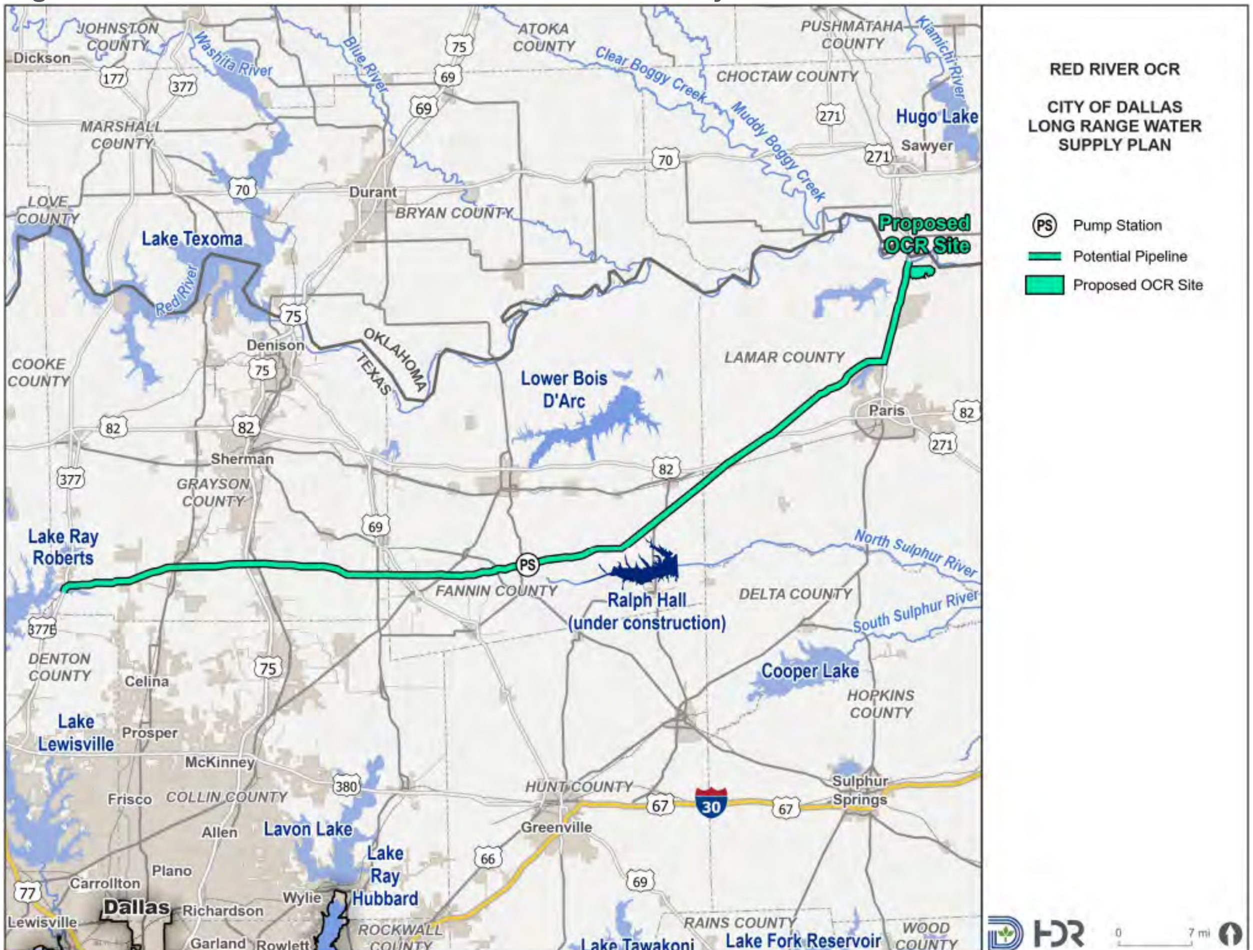
7.12 Red River OCR

The Red River Off-Channel Reservoir (OCR) project was an alternative strategy in the 2014 LRWSP. After revaluation, this strategy has been designated as an alternative strategy again in the 2024 LRWSP. The project has the potential to generate a significant amount of supply for Dallas and other regional partners. However, several key issues would need to be overcome to make the project feasible. These issues include bank stability for the intake structure along the Red River, water quality and sediment control, invasive species, and regulatory and permitting issues considering the Red River Compact.

7.12.1 Strategy Description

The Red River OCR project includes a 170 MGD (250 cfs) intake and pump station on the Red River at Arthur City, TX immediately downstream of the Highway 271 Bridge (Figure 7-36). This diversion site provides better bank stability because it is immediately downstream of the bridge abutment. The location also allows for streamflow from the Blue River and Muddy Boggy River watersheds to contribute to flow released from Lake Texoma resulting in improved water quality.

Figure 7-36. Red River Off-Channel Reservoir Project



Diversions from the Red River would be pumped approximately 2 miles via an 84-inch pipeline to three OCRs in series. The first OCR consists of a 2,500 acft basin for purposes of initial sediment settling and subsequent removal. The next OCR would consist of a 5,300 acft basin for water quality improvement and additional sediment removal. Finally, a third OCR would consist of a 32,000 acft storage basin to allow for extended pumping during those times when flow in the Red River is extremely low or water quality is impaired.

Water would then be diverted from the third OCR by a 103 MGD (159 cfs) intake and pump station and would transport, on average, about 82 MGD (92,400 acft/yr) via a 78-inch transmission pipeline to Lake Ray Roberts for subsequent blending and use by Dallas. The delivery system was designed with a 1.25 peaking factor to allow for over pumping to compensate for delivery shortages during periods when diversions from the OCR are not available. Even though zebra mussels have been found in Ray Roberts, this Red River OCR project would include provisions for zebra mussel control.

Figure 7-37 provides further detail of the OCR layout and flow of water through the three OCRs. The total area of the reservoirs is 803 acres with a total capacity of 39,800 acft. Diversions from the Red River would be discharged into the upper OCR with a conservation pool elevation of 525 ft-msl, a storage capacity of 2,500 acft and a surface area of 76 acres. Overflow from this basin would pass through an uncontrolled spillway and gravity flow to the middle OCR with a conservation pool elevation of 515 ft-msl for further sedimentation and water quality improvement. The middle OCR would have a storage capacity of 5,300 acft with a surface area of 189 acres. Discharges through the uncontrolled spillway of the middle OCR would then be gravity fed to the final OCR with a conservation pool elevation of 505 ft-msl before being diverted for delivery to Lake Ray Roberts.

The third and largest OCR storage basin was designed with an embankment height of 70 ft. The top 5 ft would be designated for freeboard and the bottom 5 ft is allocated for dead pool storage, thus leaving a conservation pool depth of 60 ft and a surface area of 533 acres. The 5 ft dead pool was included to address the high levels of sediment typically found in the Red River, which would likely settle out in the reservoir. This OCR storage basin will have an active conservation pool capacity of 32,000 acft which was originally determined in 2014 to be adequate to achieve the desired 102 MGD (114,000 acft/yr) yield based on the Red River main-stem pump station and OCR pump station capacities and the use of storage in the largest OCR. However, using the updated 2021 Red River WAM, the active conservation pool capacity of 32,000 acft now translates to a yield of 82 MGD (92,4000 acft/yr).

7.12.2 Water Availability

A yield analysis was completed using monthly available flow at Arthur City extracted from the TCEQ Red River WAM. The TCEQ WAM only models the Texas portion of the Red River basin and includes only a portion of the instream flow requirements stipulated in the Red River Compact. Figure 7-38 provides the annual available flow calculated in the 2021 version of the TCEQ WAM for the 1948 to 2018 period of record. The WAM estimates that, on average, almost 4.4 million acft/yr is available for diversion by Texas entities at Arthur City.

The monthly available flow was disaggregated to daily flows using the daily gaged flow pattern from the USGS gage at Arthur City. Diversions from the river were calculated on a daily time-step to provide a more accurate estimate of water availability from the project. Figure 7-39 shows frequency curves of the daily flow available for diversion at Arthur City compared to gaged flow. The daily available flow is compared to the gaged flow to show that additional water enters the system from the Oklahoma side of the Red River that is not included in the TCEQ WAM. The actual water available is higher when evaluated outside the confines of the TCEQ Red River WAM. Figure 7-40 shows the same frequency for lower flows at the site. The figures reveal that the 103 MGD (159 cfs) river diversion would be able to be exercised approximately 90% of the time without consideration of days with poor water quality.

Figure 7-37. Red River Off-Channel Reservoir Layout

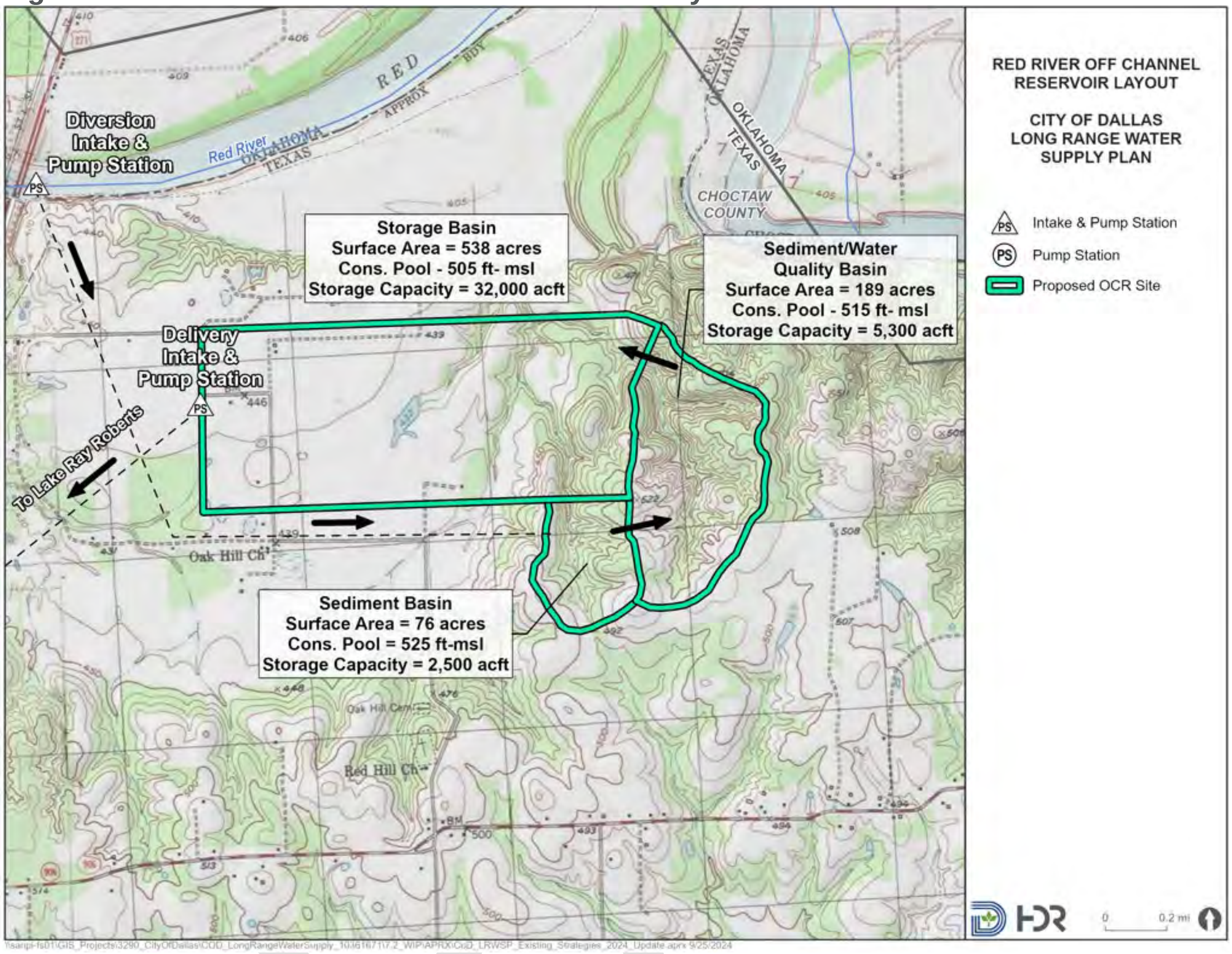


Figure 7-38. TCEQ WAM Annual Available Streamflow for Texas Entities at Arthur City Diversion Site

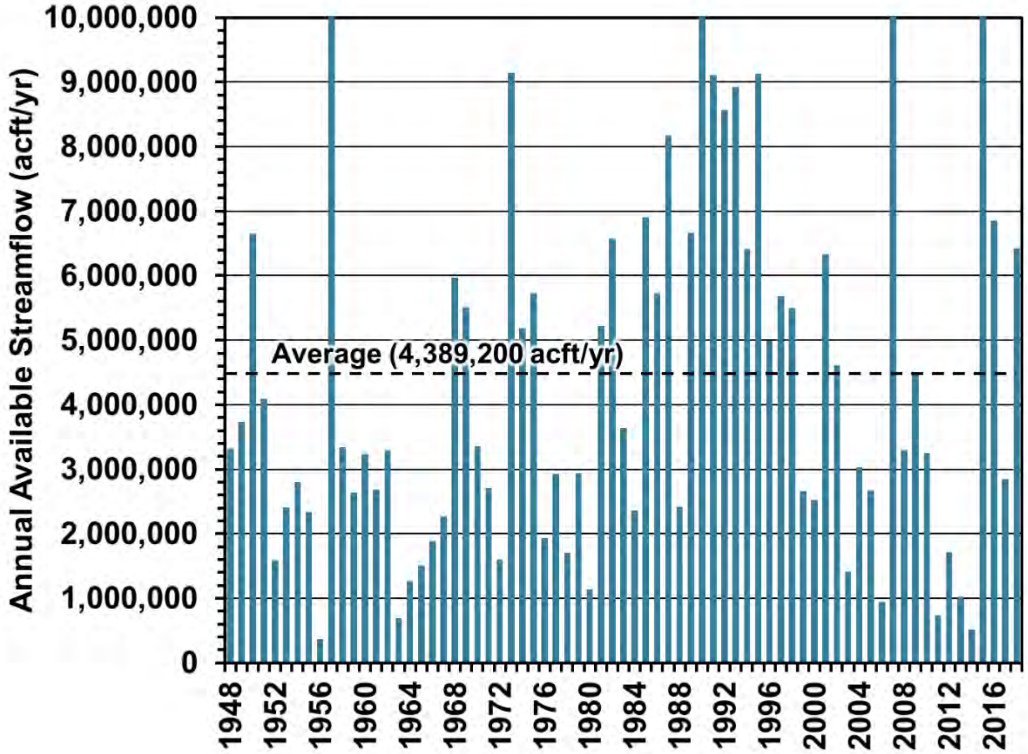


Figure 7-39. Frequency of Daily Available Streamflow at Arthur City Diversion Site

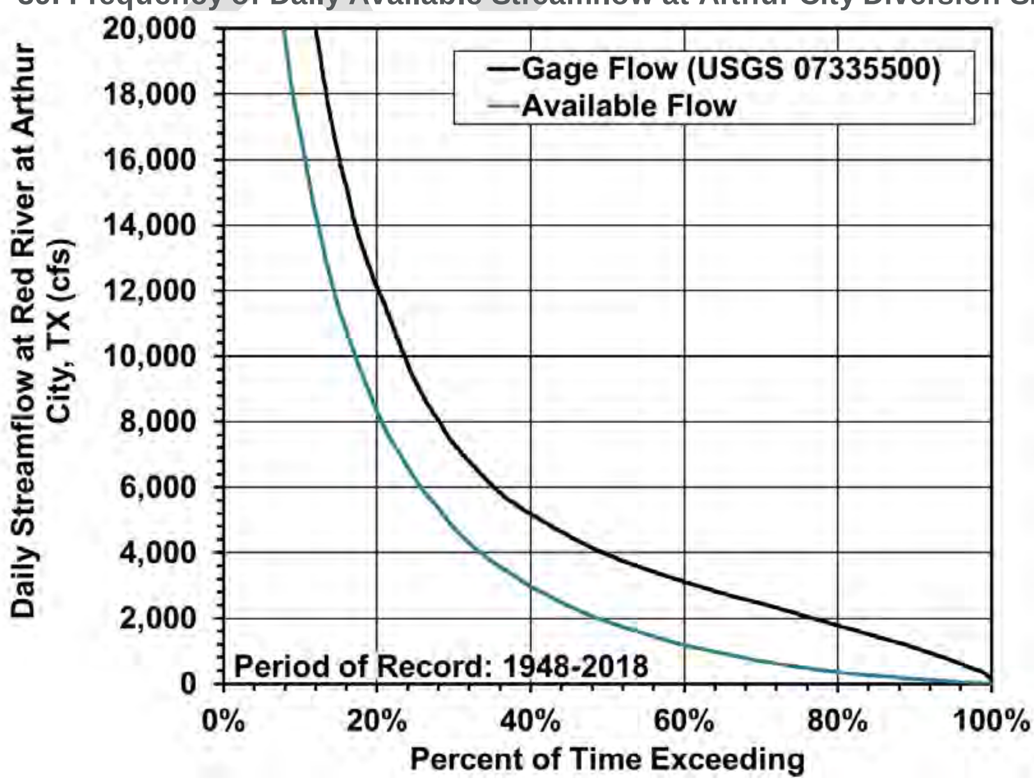


Figure 7-40. Frequency of Daily Available Low Flows at Arthur City Diversion Site

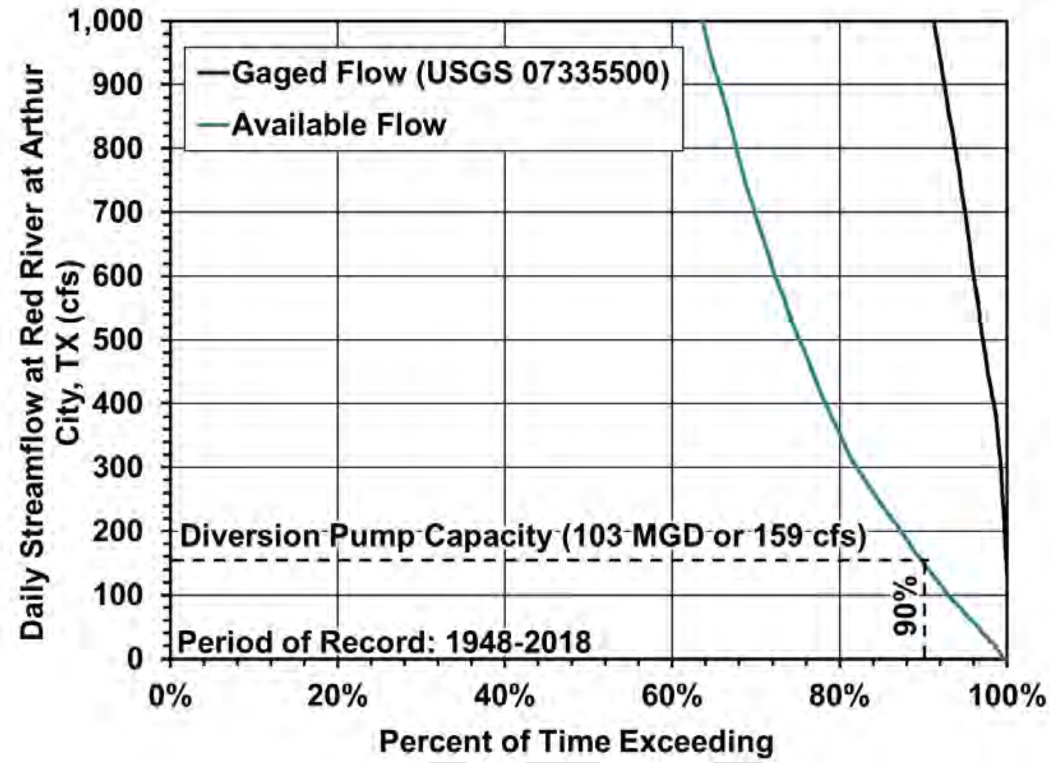


Figure 7-41 and Figure 7-42 provide time series and frequency plots of storage of the 32,000 acft OCR. For the yield analysis, the storage capacities of the two smaller OCR sedimentation basins were not considered. The storage frequency indicates that the 32,000 acft OCR would remain full almost 85 percent of the time. During the critical drought of the 1960's, the OCR reaches dead pool levels for several days. However, since the delivery pump station capacity is sized with a 1.25 peaking factor, shortages during these periods were overcome with the additional delivery capacity in the following days to keep the annual reliability at 100 percent.

Additional yield estimates previously performed in the 2014 LRWSP using higher diversion rates indicated that an expansion of the facilities would be able to provide additional regional supply with a high level of reliability.

Figure 7-41. Daily Storage of Red River OCR

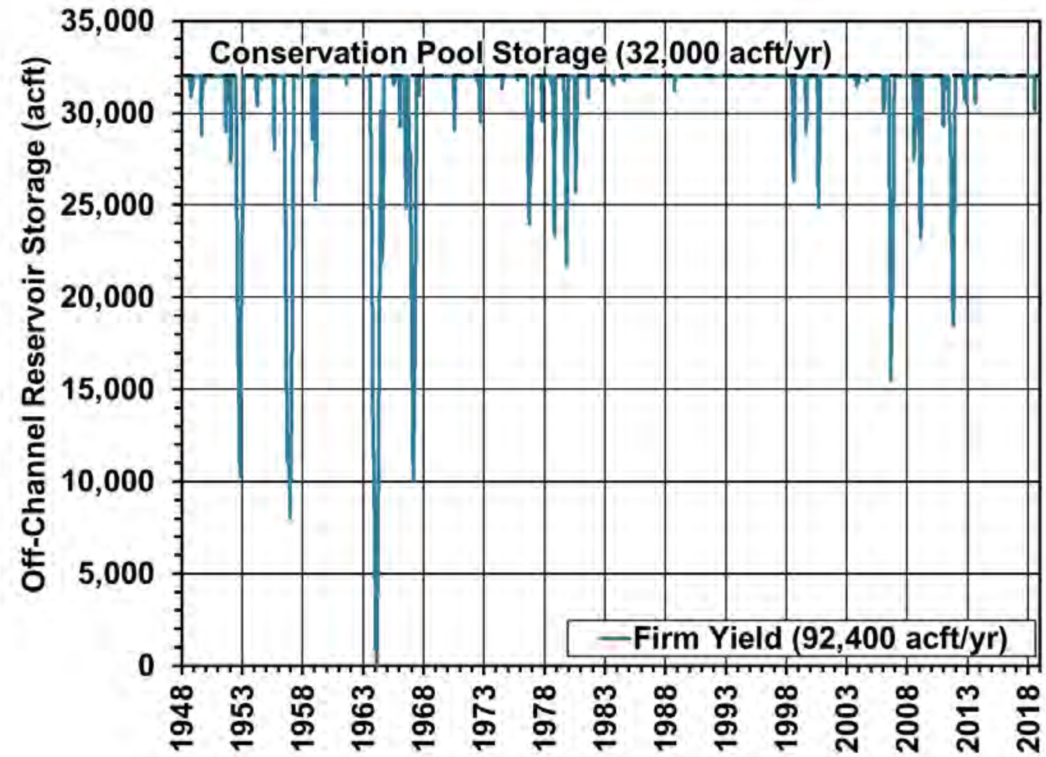
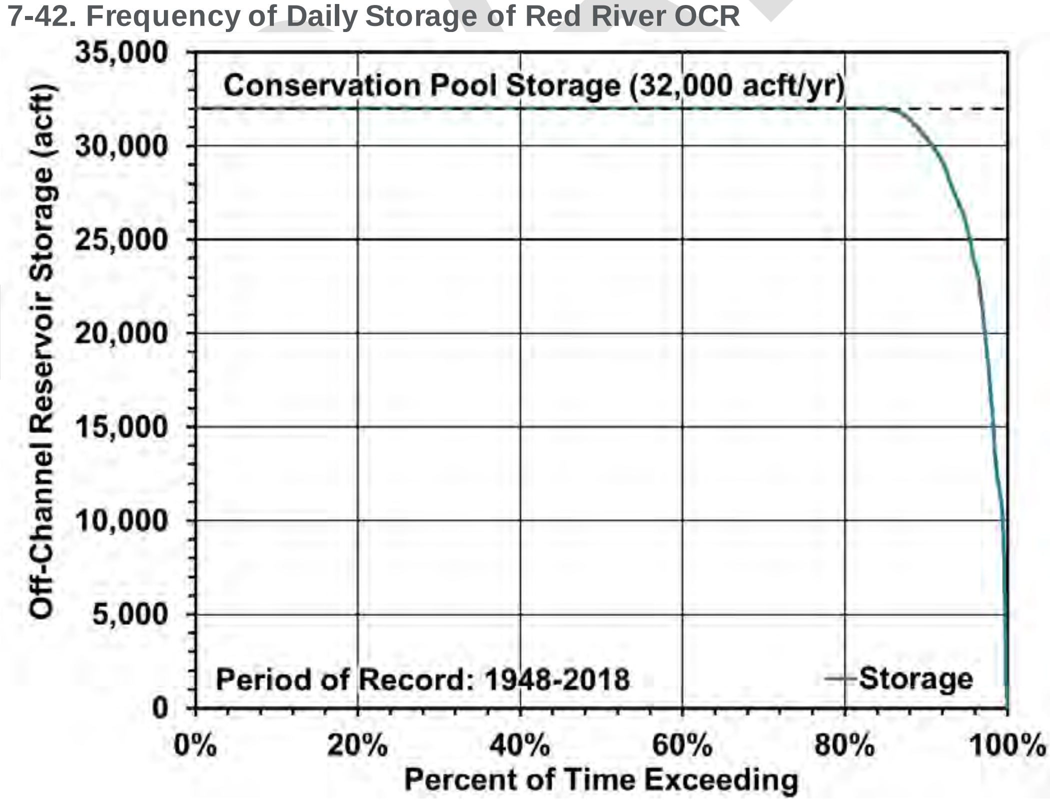


Figure 7-42. Frequency of Daily Storage of Red River OCR



7.12.3 Project Cost Estimate

The Red River OCR Project requires a 170 MGD river intake and pumping facility to be constructed on the Red River and a 2 mile, 84-inch transmission pipeline to deliver the supplies to three OCRs. A 103 MGD OCR intake facility and a 100 mile, 78-in transmission pipeline would need to be constructed to deliver supplies to Lake Ray Roberts.

A summary of project and annual costs for the Red River OCR strategy with delivery to Lake Ray Roberts is presented in Table 7-60. Annual costs include estimates for periodic dredging of the sedimentation basins and chemical addition for zebra mussel control. The costs presented in Table 7-60 do not include delivery or treatment of the supplies from Lake Ray Roberts as this is operated by Dallas as a gravity supply system.

Total project costs are estimated to be $2.06 billion with annual costs for the project assuming a 40-year debt service for reservoirs and 20 years for other project costs estimated at $173 million per year. The unit cost of water for this project to deliver water to Lake Ray Roberts would be about $1,875 per acft or $5.75 per 1,000 gallons. After debt service, the unit cost of water would decrease to $385 per acft or $1.18 per 1,000 gallons.

Table 7-60. Cost Estimate Summary for Red River Off-Channel Reservoir

Table units: September 2023 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Storage/Ring Dike (Conservation Pool 32000 acft, 800 acres)	$180,643,000
Intake Pump Stations (103.1 MGD)	$171,741,000
Transmission Pipeline (78-84 in. dia., 99.8 miles)	$968,152,000
Transmission Pump Station(s) & Storage Tank(s)	$55,127,000
Integration, Relocations, Backup Generator & Other	$9,745,000
TOTAL COST OF FACILITIES	**$1,385,408,000**
OTHER PROJECT COSTS	
- Planning (3%)	$41,562,000
- Design (7%)	$96,979,000
- Construction Engineering (1%)	$13,854,000
Legal Assistance (2%)	$27,708,000
Fiscal Services (2%)	$27,708,000
Pipeline Contingency (15%)	$145,223,000
All Other Facilities Contingency (20%)	$83,451,000
Environmental & Archaeology Studies and Mitigation	$13,838,000
Land Acquisition and Surveying (3286 acres)	$44,300,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$182,354,000
TOTAL COST OF PROJECT	**$2,062,385,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$124,043,000
Reservoir Debt Service (3.5 percent, 40 years)	$13,565,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$9,779,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$5,672,000
Dam and Reservoir (1.5% of Cost of Facilities)	$2,710,000
Water Treatment Plant	$4,191,000
Advanced Water Treatment Facility	$0
Pumping Energy Costs (0.09 $/kW-hr)	$10,549,000
Sediment Basin Dredging	$2,710,000
TOTAL ANNUAL COST	**$173,219,000**
Available Project Yield (acft/yr)	92,400
Annual Cost of Water ($ per acft), based on PF=1.25	$1,875
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.25	$385
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.25	$5.75
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.25	$1.18

7.12.4 Water Quality

Water quality is a concern for the Red River OCR strategy. Based on data from the EPA's Assessment, Total Maximum Daily Load Tracking and Implementation System, Water from Red River is impaired. Water quality constituents of concern include bacteria, total suspended solids, and total dissolved solids. Chloride Bromide, and Phosphate are less than the EPA's secondary standards. Historical data from the USGS supports these findings.

During the period from 1968 to 2012, the City of Dallas in cooperation with the US Geological Survey (USGS) conducted water quality sampling of the Red River for the reach downstream of Denison Dam and specifically at the Arthur City USGS streamgage. This sampling looked at four parameters of interest including total dissolved solids (TDS), bromide, chlorides and sulfates. This sampling shows that less than about 15% of the time, the water quality within the Red River would not meet drinking water standards for TDS (1,000 mg/L), chlorides (300 mg/L) and sulfates (300 mg/L) without blending from other water sources with better water quality. Because Dallas uses ozone in its water treatment process, the formation of bromates can be a problem when concentrations of bromides exceed about 0.2 mg/L. This concentration is exceeded at Arthur City approximately 75% of the time. To help mitigate this issue it is assumed that Dallas (and potentially other regional partners) would not operate the Red River pump station when water quality is problematic and would temporally rely on water stored in the OCR. Additionally, Dallas and other regional partners would also blend the Red River water with other water supplies to reduce bromide levels to acceptable levels.

7.12.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database and IPaC[64]; TPWD, TXNDD[65] and species county lists[66]; and the UUSGS NHD[67]. Table 7-61 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of desktop environmental factors that would need further study in feasibility or permitting efforts to address potential concerns with respective regulatory agencies.

7.12.5.1 HABITAT

The Alignment runs through Grayson, Fannin and Lamar counties. River and transmission infrastructure would be located to avoid conflicts with environmentally

[64] US Fish and Wildlife Service. (2024). *Information for Planning and Consulting (IPAC)*. Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[65] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[66] Texas Parks and Wildlife Department. (2024). *Rare, Threatened, and Endangered Species of Texas (RTEST)*. Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[67] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

sensitive areas where feasible. The OCR site primarily contains pasture areas with the eastern portion of the site including some forested areas. The majority of the pipeline route crosses areas of agricultural use including crops and pasture. Impacts to preferred habitats will be minimized by utilizing these areas which have been previously disturbed, where possible. The pipeline route also crosses through the Ray Robert Lake State Park and the Ray Robert Wildlife Management Area. Wooded riparian areas commonly occur along and adjacent to stream and river crossings that would be crossed by the pipeline corridor. Wooded areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route may also cross wetland areas which may be disturbed during construction. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities will help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing habitat from this project are anticipated to be low.

7.12.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Red River OCR project is anticipated to have a limited impact on daily flows in the Red River since average gaged streamflow from 1948 to 2018 have averaged 6.4 million acft/yr (Table 7-61), and the 170 MGD intake facility would divert less than 3 percent of the flows on average.

7.12.5.3 BAYS AND ESTUARIES

The Red River OCR Project is not anticipated to affect an estuary system as it eventually flows into the Mississippi River system and the proposed diversion of water to the Red River OCR would represent only a miniscule amount to the Mississippi River system.

7.12.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-61 represent all species federally or state listed as threatened or endangered, and federal candidate and proposed species in the counties for which the project will be located. The project area includes 17 species that meet these criteria (RTEST and county species lists). These species would need to be considered throughout the design process and potentially mitigated during project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species which occur within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project. There are currently no areas of designated or proposed critical habitat within the project area (TXNDD).

7.12.5.5 WETLANDS

Although a number of NWI-Mapped wetlands occur along the proposed pipeline corridor, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas. Impacts to wetlands associated with this project are anticipated to be low.

7.12.5.6 AGRICULTURAL AND NATURAL RESOURCES

The OCR would permanently impact an estimated 399 acres of soils identified by the USDA as prime farmland soils. This represents less than 1 percent of the total prime farmland soils found in Lamar County. Construction activities associated with the project pipeline would impact an additional 323 acres of prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to the original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the other Environmental Impacts sections above.

Table 7-61. Environmental Factors for Red River OCR Project

Environmental Factors	Comment(s)
Habitat	No presence of critical or unique habitat in project area. Low Impact
Environmental Water Needs	The project would divert less than 3% of flows on average. Low Impact
Bays and Estuaries	Diversions from the project are insignificant to the Mississippi River System. Low Impact
Threatened and Endangered Species	tricolored bat (FPE), white-faced ibis (ST), wood stork (ST), black rail (ST), shovelnose sturgeon (ST), paddlefish (ST), chub shiner (ST), black bear (ST), alligator snapping turtle (FPT, ST), Texas horned lizard (ST), northern scarlet snake (ST), whooping crane (SE, FE), blue sucker (ST), Texas heelsplitter (ST). Texas fawnsfoot (FT), American burying beetle (FT), monarch butterfly (C). Low to Medium Impact
Wetlands	There are wetlands located along the proposed pipeline corridor. Low Impact
Agriculture and Natural Resources	Less than 1% of prime farmland soils in Lamar County are impacted by the project. Low Impact

Source: USFWS, 2024 and TPWD 2024.

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered. ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

7.12.6 Confidence and Permitting

The Red River OCR project would pose several unique permitting challenges along with the typical challenges associated with a new project. Similar to other new water projects in Texas, Dallas would need to obtain a water rights permit for the river diversion from the TCEQ including an interbasin transfer authorization. In addition to the water rights permit, Dallas would likely need to obtain a 404 permit from the USACE for impacts to a waters of the U.S. from construction activities. Table 7-30 provides a summary of potential permitting requirements.

Diversions from the Red River would potentially need to comply with provisions of the Lacey Act which prohibits the transport of non-native species across state boundaries, and in this case, zebra mussels. The state boundary of Texas is defined as the southern bank of the main channel of the Red River, and therefore, the intake and pump station facilities would need to be constructed within the Texas state boundary to avoid having to comply with the provisions of the Lacey Act. However, if this is not possible, it may be possible to obtain special legislation allowing the diversion similar to efforts undertaken by NTMWD which allowed for the transfer of Lake Texoma water into the Trinity River Basin.

Table 7-62. Potential Permitting Requirements

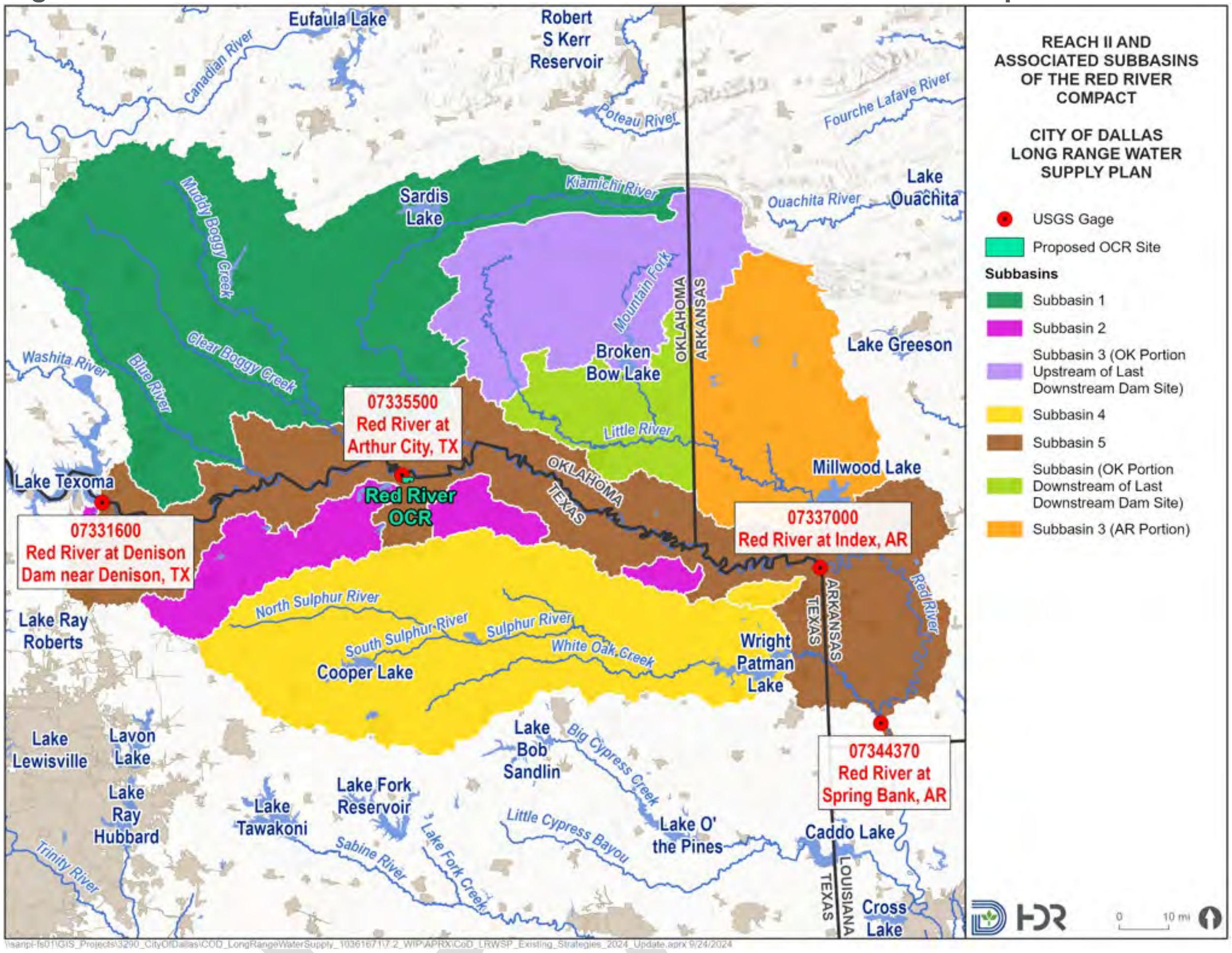
Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit	TCEQ	Will require an inter-basin transfer authorization to transfer water to the Trinity River Basin.
Section 404	USACE	Required for construction activities in waters of the U.S.

Diversion from the Red River would also need to comply with all provisions included in the Red River Compact[68]. The diversion at Arthur City would be located in Reach II, Subbasin 5 of the Red River Compact. Under Section 5.05 of the Compact, the main stem of the Red River within Reach II (i.e. subbasin 5) is defined as “that portion of the Red River, together with its tributaries, from Denison Dam down to the Arkansas-Louisiana State boundary, excluding all tributaries included in the other four subbasins of Reach II”. Figure 7-43 provides the Reach II associated subbasin boundaries as defined by the Red River Compact. In addition, Figure 7-43 shows the location of the USGS Gage at Arthur City where the proposed diversion would be located.

Section 5.05 defines how water is allocated within subbasin 5. Subsection 5.05(b) (1) states that “The Signatory States shall have equal rights to the use of runoff originating in subbasin 5 and undesignated water flowing into subbasin 5, so long as the flow of the Red River at the Arkansas-Louisiana state boundary is 3,000 cfs or more, provided no state is entitled to more than 25 percent of the water in excess of 3,000 cfs.” Table 7-63 provides the average and minimum annual flow at USGS Gage 07344370 on the Red River at Spring Bank, AR near the Arkansas-Louisiana boundary for the 1998 to 2024 gage period of record. Table 7-63 also provides the approximate portion of available flows of subbasin 5 that Texas is entitled to. On average, Texas is entitled to approximately 3.6 million acft/yr of the available flow in subbasin 5. In the minimum year of the gage period of record (2006) there was 675,039 acft of available flow to Texas in subbasin 5.

[68] http://www.statutes.legis.state.tx.us/Docs/WA/htm/WA.46.htm

Figure 7-43. Reach II and Associated Subbasins of the Red River Compact



This amount of available flow is about 800,000 acft/yr less than the average annual available flow calculated in the TCEQ WAM. The discrepancy in available flow is a result of the TCEQ including only a portion of the Red River Compact stipulations and not including inflows into the main stem of the Red River from Oklahoma tributaries or Oklahoma water rights and reservoirs. In addition, the TCEQ WAM and gaged flows used to estimate values in Table 7-63 do not have similar periods of record. The gaged flows at the Arkansas-Louisiana boundary were only available after the WAM period of record and contain several drought periods including the drought of 2011 – 2015.

7.12.7 Flexibility and Phasing

The Red River Off-Channel Reservoir has flexibility incorporated in several ways. The three off-channel reservoir system proposed for the Red River OCR project, which is described in the strategy description, offers an opportunity for operational flexibility with regard to water quality. Further flexibility is added to the project by designing the delivery system with a 1.25 peaking factor to allow for over pumping to compensate for delivery shortages during periods when diversions from the OCR are not available. This project also offers the opportunity for several regional partnerships.

The project could provide supplies to multiple potential regional partners including NTMWD (Lake Lavon, Lake Chapman, Lower Bois d'Arc Reservoir), City of Irving (Lake Chapman delivery to Lake Lewisville) and UTRWD (Lake Ralph Hall or Lewisville Lake). Additionally, the pipeline could be extended further west to potentially supply water to the TRWD system at either Lake Bridgeport or Eagle Mountain Reservoir and potentially to the Brazos River Basin to a location near Possum Kingdom Reservoir for use by west Texas entities that are currently experiencing one of the worst historical droughts. Supplies could also be delivered to a tributary of Lake Tawakoni where they could be blended with water in Dallas' eastern supply system.

The flexibility of the project may be constrained by several risks. As with any project, there are inherent risks to eventual implementation and development. These risks can be permitting risks, mitigation risks, performance risks, and/or risks associated with various types of conflict. The Red River OCR project possesses a high level of risk associated with permitting as discussed in the environmental impacts subsection. In addition, this project is susceptible to performance risk associated with a worse drought of record and future upstream impoundments. A significant portion of the available flow to the project originates in the Blue and Muddy Boggy River watershed located in Oklahoma. If large reservoirs are constructed in these watersheds, then available flow to the project could be reduced.

Table 7-63. Gaged Flow and Texas Portion of Available Flow in Reach II, Subbasin 5 of Red River Compact

Table units: acft

YEAR	Gaged Streamflow	Texas Portion of Available Streamflow
1998	18,705,114	4,133,343
1999	9,553,978	1,868,701
2000	11,895,008	2,437,119
2001	25,022,248	5,712,587
2002	19,431,282	4,315,728
2003	7,117,028	1,246,452
2004	10,018,705	1,961,627
2005	8,135,381	1,543,259
2006	4,550,219	675,039
2007	23,151,954	5,245,014
2008	16,569,036	3,603,697
2009	24,721,633	5,637,433
2010	12,581,983	2,640,430
2011	6,896,069	1,248,024
2012	8,900,326	1,790,473
2013	7,053,021	1,237,834
2014	7,384,776	1,318,978
2015	38,111,622	8,984,931
2016	29,025,188	6,716,922
2017	11,053,759	2,225,567
2018	21,947,215	4,949,551
2019	29,113,214	6,735,329
2020	24,433,693	5,564,164
2021	20,859,956	4,696,852
2022	8,533,919	1,611,961
2023	16,195,489	3,505,897
2024	15,454,583	3,467,854
Average	**16,510,929**	**3,609,817**
Min (2006)	**4,550,219**	**675,039**

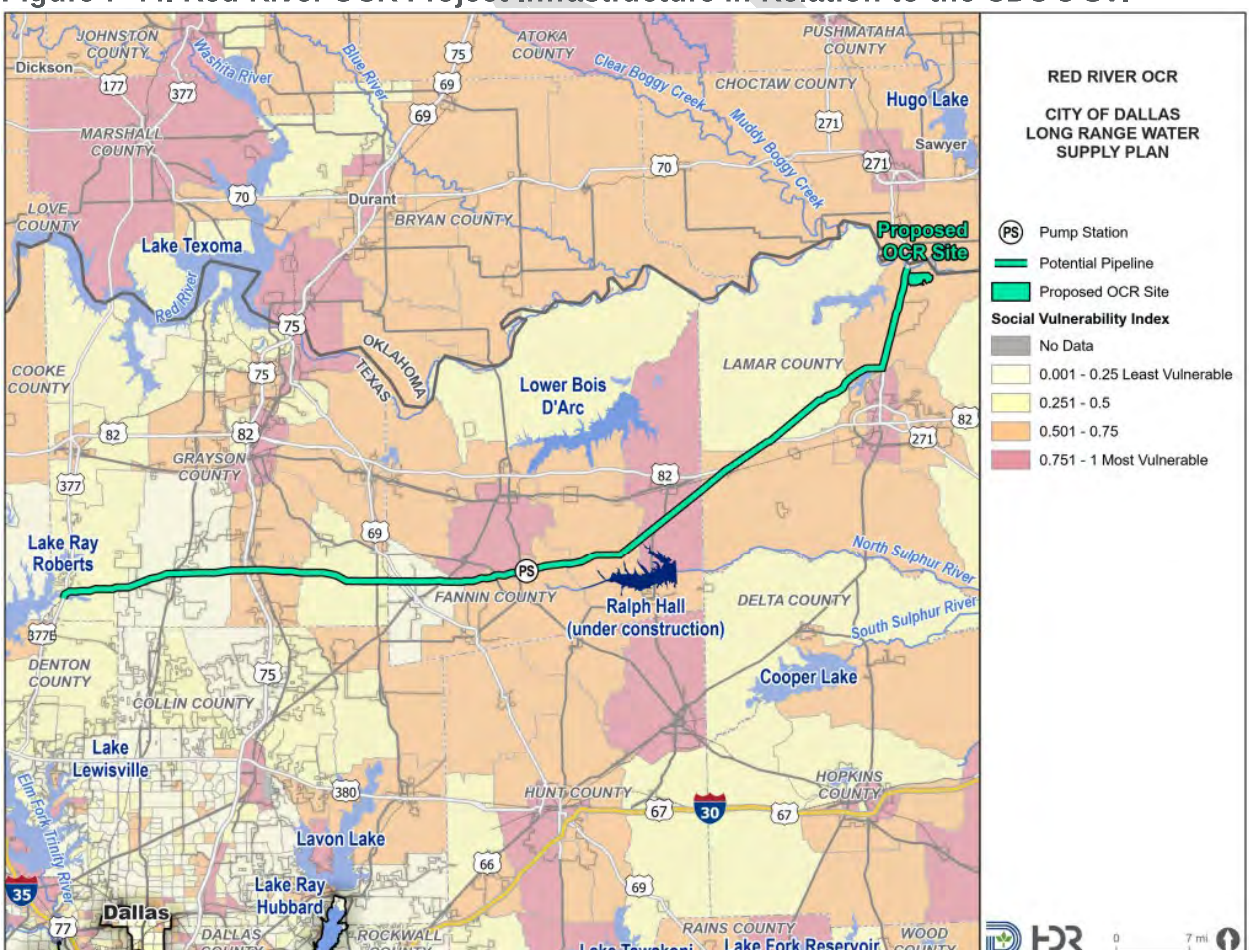
7.12.8 Equity Impacts

Impacts to equity from implementation of the Red River OCR strategy may result from placement of potential project infrastructure such as the off-channel reservoir, intake, pump stations, and transmission pipelines. Equity was evaluated by examining the percent area of project components located within each quartile of the CDC's Social Vulnerability Index. (see Table 7-64. Red River OCR SVI Quartile Distribution and Figure 7-44). The project infrastructure is located in all quartiles of the CDC's SVI; the off-channel reservoir is located in the 3rd quartile, the pump station is in the 3rd quartile, and the transmission pipeline goes through all quartiles). Sixty-eight percent of the project is located in the 3rd and 4th quartiles of the CDC's SVI, meaning that much of the infrastructure for this project is located in areas likely to experience significant equity impacts.

Table 7-64. Red River OCR SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
14.4%	18.1%	59.1%	8.4%	**2**

Figure 7-44. Red River OCR Project Infrastructure in Relation to the CDC's SVI



7.13 Interstate - Kiamichi River

This is an interstate strategy that evaluates the diversion of a large supply of water from an entity in Oklahoma. Kiamichi River in Oklahoma is a new strategy that is evaluated in the 2024 LRWSP and has been designated as an alternative strategy.

The Kiamichi River is located in the Red River basin in southeast Oklahoma. Downstream of Hugo Lake, the Kiamichi River flows about 18 miles before its confluence with the Red River. The Kiamichi River typically sees flows from 22,000 to 77,000 acft/month.

7.13.1 Strategy Description

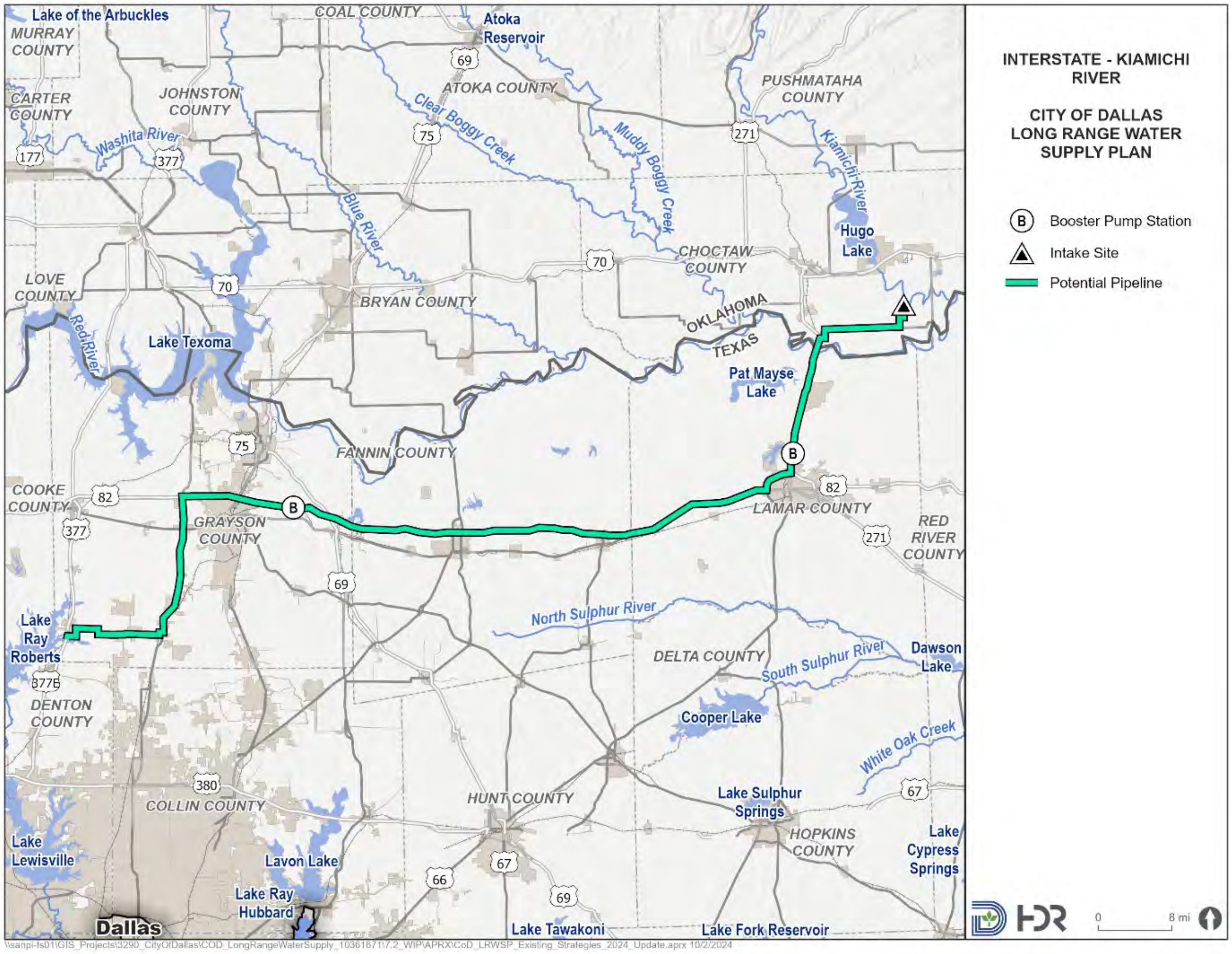
Past strategy evaluations regarding the purchase of water from Oklahoma via permit from the Oklahoma Water Resources Board (OWRB) were unsuccessful due to the U.S. Supreme Court ruling that Texas does not have the right to a permit for water from the portions of Southeastern Oklahoma governed by the Red River Compact. However, as time has passed, Oklahoma may have an increased interest in selling water to Texas through an interstate water agreement.

The water supply from Oklahoma is assumed to be diverted from the Kiamichi River, downstream of Hugo Lake and delivered to Lake Ray Roberts. It is assumed for the purpose of this analysis that a total of 268 MGD (300,000 acft/yr) could be purchased and delivered to serve DWU and its customer cities.

The channel dam and intake pump station associated with the project is located in Choctaw County, Oklahoma. A 125-mile pipeline with 2 booster pump stations would be needed to deliver supplies from the Kiamichi River to Lake Ray Roberts (Figure 7-45). An outfall structure is needed to reduce residual head at the pipeline outlet at Lake Ray Roberts.

The water supply could be secured via a permit with OWRB, an agreement with the Native American Tribes in Oklahoma, and/or a contract with an Oklahoma entity willing to sell water rights they own.

Figure 7-45 Interstate – Kiamichi River to Lake Ray Roberts



7.13.2 Water Availability

It is assumed that 268 MGD (300,000 acft/yr) of water would be available for purchase from the Kiamichi River in Southeastern Oklahoma. This volume is based on a past independent yield analysis and a previous water right application by Tarrant Regional Water District (TRWD) to the Oklahoma Water Resources Board (OWRD). It is assumed that there have been no significant reductions to supply. The Kiamichi River downstream of Hugo Lake and Gates Creek typically sees flows from 22,000 to 77,000 acft/month (2012), with an average annual flow of 594,000 acft/year. The Oklahoma Comprehensive Water Plan (OCWP) is currently being updated for 2025 and improved information regarding supply availability in the Kiamichi River may be available upon completion of that report.

Based on the OWRB water viewer, there have been a total of 35 new surface water permits between 2021 and 2023, and currently no pending surface water permits in Choctaw county.

7.13.3 Project Cost Estimate

The following facilities are required to deliver water from the Kiamichi River to Lake Ray Roberts:

- Channel dam and a 281 MGD intake and pump station.
- Approximately 125 miles of 132-inch transmission pipeline from Kiamichi River to Lake Ray Roberts.
- Two booster pump stations along the pipeline route, both 19,371 HP.
- Outfall structure at Lake Ray Roberts

A summary of total project costs of the project for the Kiamichi River pipeline is listed in Table 7-65. The total project costs are $4.26 billion. Annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and are estimated to be $360,977,000 per year. The raw water purchase cost from ORWB or an Oklahoma entity would need to be negotiated as part of project implementation, and therefore not included in this cost estimate. The unit cost of water for this project is $1,203 per acft or $3.69 per 1,000 gallons. The unit cost is based on the assumed 268 MGD (300,000 acft) of water available for purchase and excludes the raw water purchase cost.

Table 7-65. Cost Estimate for Kiamichi River Pipeline to Lake Ray Roberts

Table units: September 2023 Dollars

Item	Estimated Costs for Facilities
CAPITAL COST	
Channel Dam	$12,609,000
Intake Pump Stations (281.2 MGD)	$91,466,000
Transmission Pipeline (132 in. dia., 124.5 miles)	$2,702,120,000
Transmission Pump Station(s) & Storage Tank(s)	$139,846,000
Backup Generator & Outfall Structure	$24,996,000
TOTAL COST OF FACILITIES	**$2,971,037,000**
OTHER PROJECT COSTS	
Engineering	
- Planning (3%)	$89,131,000
- Design (7%)	$207,973,000
- Construction Engineering (1%)	$29,710,000
Legal Assistance (2%)	$59,421,000
Fiscal Services (2%)	$59,421,000
Pipeline Contingency (15%)	$405,318,000
All Other Facilities Contingency (20%)	$53,784,000
Environmental & Archaeology Studies and Mitigation	$3,752,000
Land Acquisition and Surveying (1,524 acres)	$2,193,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$376,521,000
TOTAL COST OF PROJECT	**$4,258,261,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$298,209,000
Reservoir Debt Service (3.5 percent, 40 years)	$0
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$27,271,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$5,783,000
Channel Dam (1.5% of Cost of Facilities)	$189,000
Pumping Energy Costs (0.09 $/kW-hr)	$29,525,000
TOTAL ANNUAL COST	**$360,977,000**
Available Project Yield (acft/yr)	300,000
Annual Cost of Water ($ per acft), based on PF=1.05	$1,203
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.05	$209
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.05	$3.69
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.05	$0.64

7.13.4 Water Quality

The Kiamichi River downstream of Hugo Lake is impaired for fish and wildlife propagation, fish consumption, and public and private water supply uses due to lead levels in the water that are exceeding the threshold for this reach of the Kiamichi River. The Kiamichi River is listed on the Clean Water Act 303(d) Report and there is not currently a restoration plan in place. Potential sources contributing to this impairment could be highway/road/bridge runoff and impacts from abandoned mine lands.

7.13.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) Database and Information, Planning, and Conservation System (IPaC); Texas Parks and Wildlife Department (TPWD) Texas Natural Diversity Database (TXNDD) and species county lists; Oklahoma Department of Wildlife Conservation; and the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD). Table 7-49 summarizes the environmental factors that would need to be considered during this project's permitting and implementation. These categories provide a general summary of conditions that would need further study in feasibility or permitting efforts to address potential concerns with respective regulatory agencies.

7.13.5.1 HABITAT

The intake pump station, pipeline, and outfall structure will be located to avoid conflicts with environmentally sensitive areas, where feasible. According to the USFWS Information for Planning and Consultation (IPaC) resource list dated July 23, 2024, there are currently no areas of designated critical habitat within the project area (USFWS, 2024). The majority of the pipeline route crosses areas of agricultural use including crops and pasture, based on aerial photographs. Impacts to preferred habitats will be minimized by utilizing areas which have been previously disturbed to the extent practicable. The pipeline corridor crosses the Red River, a perennial stream, and several named creeks. The wooded riparian areas that occur along and adjacent to stream and river crossings are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route may also cross NWI-identified wetland areas which could be disturbed during construction. The use of siting to avoid and/or minimize impacts during design and utilizing BMPs during construction activities would help to minimize potential impacts to the discussed sensitive natural areas.

Specific project components such as pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, impacts to existing habitat from this project are anticipated to be low.

7.13.5.2 ENVIRONMENTAL WATER NEEDS

The Kiamichi River typically sees flows from 22,000 to 77,000 acft/month (2012). A volume of 300,000 acft/yr would be just under one-third of the yearly peak flow volume, which could impact riparian and aquatic habitat downstream of the intake pump station until the Kiamichi River's confluence with the Red River. Coordination with Oklahoma Department of Wildlife Conservation may be required.

7.13.5.3 BAYS AND ESTUARIES

The Kiamichi River is a tributary of Red River, which eventually flows into the Mississippi River Delta. Downstream of the Kiamichi River/Red River confluence, the Red River experiences a flow of 2.6 million acft/year. The proposed 300,000 acft/year diverted from the Kiamichi River is of negligible impact to the Mississippi River Delta's aquatic conditions.

7.13.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-49 represent all federally or state-listed species and federal candidate and proposed species in the counties for which the project will be located. The pipeline route traverses potential habitat for 23 listed species. These species would need to be considered through the design process and could potentially require mitigation measures during the project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area counties will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.13.5.5 WETLANDS

Although a number of potentially jurisdictional wetlands occur along the proposed pipeline corridor, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas. Impacts to wetlands associated with this project are anticipated to be low.

7.13.5.6 AGRICULTURAL AND NATURAL RESOURCES

Within a 50-foot buffer of the pipeline, Kiamichi River to Lake Ray Roberts would temporarily or permanently impact an estimated 64 acres of soils identified by the USDA as prime farmland soils in Texas[69]. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because the pipeline areas will be allowed to return to original land uses after construction of the underground pipeline is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Issues section above.

[69] Farmland soil data insufficient to make a determination in Oklahoma.

Table 7-66 Environmental Factors for the Interstate – Kiamichi River OK Project

Environmental Factors	Comment(s)
Habitat	No presence of critical or unique habitat in project area. Low Impact
Environmental Water Needs	Low Impact
Bays and Estuaries	Low Impact
Threatened and Endangered Species	northern long-eared bat (FE), tricolored bat (FPE), piping plover (FT ST), rufa red knot (FT ST), whooping crane (FE SE), alligator snapping turtle (FPT ST), Ouachita rock pocketbook (FE), scaleshell mussel (FE), Texas fawnsfoot (FT), winged mapleleaf (FE), American burying beetle (FT), monarch butterfly (C), white-faced ibis (ST), wood stork (ST), black rail (ST), shovelnose sturgeon (ST), paddlefish (ST), chub shiner (ST), blue sucker (ST), black bear (ST), Texas horned lizard (ST), northern scarlet snake (ST), Texas heelsplitter (ST), blackside darter (ST) Medium Impact
Wetlands	Low Impact
Agricultural and Natural Resources	Temporary impacts to 64 acres of USDA prime farmland soils. Low impact

Source: USFWS, 2024 and TPWD 2024

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.

ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

7.13.6 Confidence and Permitting

Water supply from the Kiamichi River will require a water right permit in order to begin the development of a water supply project. Due to the U.S. Supreme Court Ruling in 2013 over Tarrant Regional Water District v. Herrmann, a water permit directly with the Oklahoma Water Resources Board is unlikely. However, there are two additional options in acquiring a water right to the Kiamichi River. One option would involve the Native American Tribes in Oklahoma legally quantifying their water rights and then selling water to DWU. The other option is for DWU to enter into a water supply agreement with an entity in Oklahoma that holds a water right to the Kiamichi River. Contracting through an Oklahoma entity would require approval from Oklahoma legislature.

A USACE Section 404 permit from the Tulsa District (expected lead agency) would be required as part of the intake pump station, pipeline construction, and outfall for impacts which occur below the ordinary high-water mark (OHWM) of a jurisdictional water.

The Kiamichi River is part of the Red River Compact therefore, all permitting, and acquisition of water rights done by DWU will need to comply with the compact. The potential permitting requirements are shown in Table 7-67.

Potential risk associated with this strategy is the Lacey Act. The Lacey Act may inhibit this strategy should there be identification of an invasive or “injurious species” (as defined by the Lacey Act) in the Kiamichi River. The potential conveyance of an invasive, non-native species across state boundaries via pipelines may be subject to federal, commerce, civil, and/or criminal penalties. This strategy does have flexibility to reduce the risk of the conveyance of non-native species across state boundaries should invasive and injurious species be identified in the Kiamichi River. A new project configuration forgoing direct transfer to a reservoir and instead delivering the water supply directly to a new water treatment plant may be required. It is anticipated that a 281 MGD water treatment plant would satisfy potential mitigation requirements. Coordination with U.S. Fish & Wildlife Service and seeking legislative relief from the Lacey Act should invasive species be identified in the Kiamichi River would be expected to pose significant challenges.

Table 7-67 Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Contract	ORWB or OK Entity	Requires an agreement of authorization for Dallas to transport and use the water.
Section 404	USACE	Required for construction activities in waters of the U.S.

7.13.7 Flexibility and Phasing

Development and implementation of this strategy would come with inherent risks related to permitting and environmental impacts since the project would divert 300,000 acft/yr of water.

There is flexibility in the current project delivery location. A different reservoir could be identified as the delivery location should DWU subsystem needs arise that could be met through this water supply.

No project partners were identified or considered for this analysis. However, there would be opportunities for partnership with other North Texas water providers on this project to reduce project costs.

7.13.8 Equity Impacts

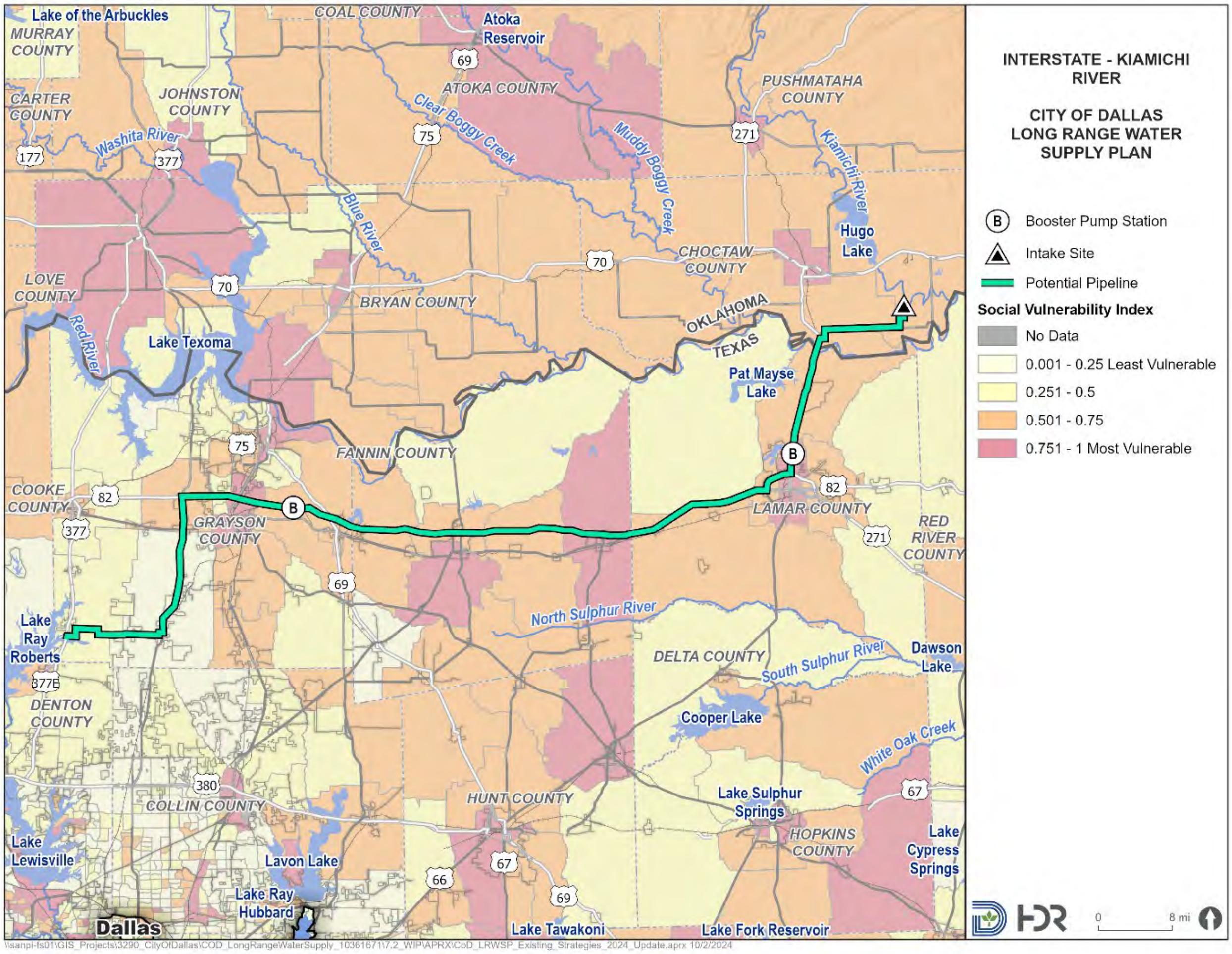
Impacts to equity from implementation of the Kiamichi River strategy may result from placement of project infrastructure such as the transmission pipeline, intake pump station, or booster pump stations. A reasonable project alignment was chosen based off preliminary engineering judgment.

Equity was evaluated by looking at the amount of area per quartile where project components are proposed to be located. The land area required for the pump stations and pipeline were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-68. A visual representation of the quartile distribution is shown in Figure 7-46.

Table 7-68. Interstate – Kiamichi River OK SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
13.9%	13.3%	60.2%	12.6%	**3**

Figure 7-46. Interstate – Kiamichi River OK Project Footprint with SVI Visual



Based on the results, over half of the project area is projected to reside in areas with an increased vulnerability to equity impacts. The large distribution of project area residing in the 3rd quartile indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 3 based on the equity criteria scoring guidelines indicating that this project may have neutral impacts to socially vulnerable communities and is not expected to provide enhancement to said communities.

Mitigation for implementation of this strategy would not be necessary. However, mitigation efforts would be effective in removing the majority of project burdens from the socially vulnerable communities.

7.13.9 References

Arkansas Natural Resources Commission. (2014, November 24). *Arkansas Water Plan Update 2014.* Retrieved from Arkansas Water Plan: https://www.arwaterplan.arkansas.gov/plan/ArkansasWaterPlan/2014AWPWaterPlan/App%20C_Water%20Availability%20Report_Final_11.24.14.pdf

Brown & Root, Inc. (1991, July). *Yield Study Toledo Bend Reservoir.* Retrieved from Texas Water Development Board: https://www.twdb.texas.gov/publications/reports/contracted_reports/doc/90483770.pdf

Emergent Method. (2018, November 30). *Water Resources Final Commission Final Report.* Retrieved from Louisiana Department of Natural Resources: https://www.dnr.louisiana.gov/assets/OC/env_div/gw_res/WRC_Final_Report_113018.pdf

Environmental Protection Agency. (2020). *Little River-Millwood Lake Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Proection Agency: https://mywaterway.epa.gov/waterbody-report/ARDEQH2O/AR_11140109_4020/2020

Environmental Protection Agency. (2022). *Kiamichi River Waterbody Report*. Retrieved July 15, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/OKDEQ/OK410300010010_00/2022

Environmental Protection Agency. (2024). *Toledo Bend Reservoir Waterbody Report*. Retrieved July 2015, 2024, from United States Environmental Protection Agency: https://mywaterway.epa.gov/waterbody-report/LADEQWPD/LA110101_00

HDR and Buhman Associates, LLC. (2010). *Evaluation of Water Supply Alternatives for the Kiamichi River, Cache Creek, and Beaver Creek.* unpublished by may be obtainable from TRWD.

Oklahoma Water Resources Board. (2011, October). *2012 Oklahoma Comprehensive Water Plan.* Retrieved from Oklahoma Water Resources Board: https://oklahoma.gov/content/dam/ok/en/owrb/documents/water-planning/ocwp/southeast-planning-region-report.pdf

Oklahoma Water Resources Board. (2024). *Water use Permits in Oklahoma*. (ArcGIS) Retrieved June 10, 2024, from Oklahoma Water Resources Board: https://owrb.maps.arcgis.com/apps/dashboards/6e5e1ce9c3a640b3a484e430d4db8139

US Army Corps of Engineers. (2022). *Millwood Lake Master Plan Shoreline Management Plan Revision*. Retrieved from US Army Corps of Engineers: https://www.swl.usace.army.mil/Missions/Planning/Millwood-Lake-Master-Plan-Revision/Documents/

USGS. (2024, September 2024). *NAS - Nonindegenous Aquatic Species*. Retrieved September 4, 2024, from USGS: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=5

7.14 Lake Texoma Desalination

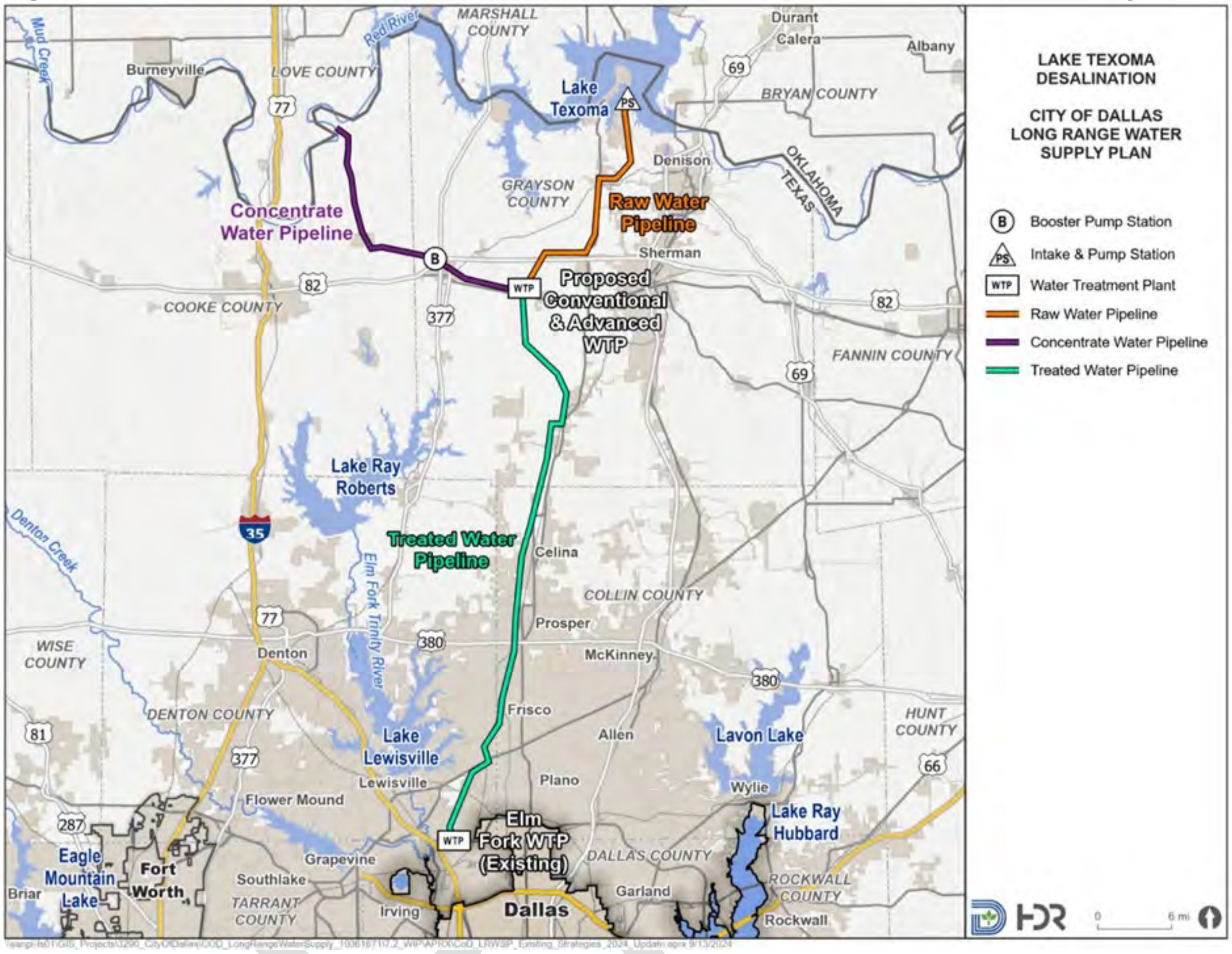
The Lake Texoma Desalination Strategy was an alternative strategy in the 2014 LRWSP and remains an alternative strategy in the 2024 LRWSP. Lake Texoma's size and proximity to Dallas continues to make the strategy relevant; however, the expected challenges of obtaining a water right permit on Lake Texoma, and the strategy's cost has caused it to rank lower than the recommended strategies.

Lake Texoma is an 89,000-acre US Army Corps of Engineers (USACE) reservoir constructed in 1944 and located on the Red River on the border between Texas and Oklahoma approximately 50 miles north of the DFW Metroplex. It is authorized for flood control, hydropower, water supply, and recreation and has a conservation pool capacity of 2,516,232 acft.

7.14.1 Strategy Description

Lake Texoma has elevated levels of dissolved solids, chlorides and sulfates, and the water must be either blended with higher quality water or desalinated for municipal use. To utilize this supply would require a raw water intake and transmission line to a treatment facility, a treatment and desalination facility to pre-treat the entire supply and desalinate 50 percent of the supply, disposal of concentrate back upstream of the lake into the Red River (where stream standards allow for higher concentrations of dissolved minerals), and then pump the treated water to the clear wells at DWU's Elm Fork WTP. Figure 7-47 shows Lake Texoma's location in relation to the Dallas system, along with the proposed pipeline routes, and proposed location of the treatment facility.

Figure 7-47. Lake Texoma Advanced Water Treatment Plant and Transmission Pipelines



7.14.2 Water Availability

Under the terms of the Red River Compact, the yield of Lake Texoma is divided equally between Texas and Oklahoma. The firm yield of the storage amount allocated to Texas is 283 MGD (316,550 acft/yr) and has already been fully permitted by the TCEQ to other Texas entities. According to the USACE, an additional supply of 196 MGD (220,000 acft/yr) could potentially be made available to Texas entities if the U.S. Congress authorizes the reallocation of hydropower storage in Lake Texoma to municipal water supply. Additionally, Oklahoma's portion of the municipal supply could be purchased by DWU if Oklahoma entities were willing to sell some part of the Lake Texoma allocation up to 162,271 acft/yr. This would require a contract or permit between Oklahoma entities and DWU.

7.14.3 Project Cost Estimate

The total cost of the project in September 2023 dollars is estimated to be $3.8 billion. Annual costs for the project are estimated at $431 million per year. During debt service, the unit cost of water from the Lake Texoma Desalination Strategy is projected to be roughly $2,953 per acft, which is close to $9.06 per 1,000 gallons. Project facilities for raw water delivery and treatment will include the following components:

- A 181 MGD intake (a 1.25 peaking factor) and pump station at Lake Texoma,
- 23 miles of 90-inch diameter raw water transmission pipeline,
- A 181 MGD conventional WTP,
- A 90 MGD reverse osmosis WTP (for desalinating up to 50% of the supply),
- 25 miles of 30-inch diameter pipeline for concentrate disposal, and
- 50 miles of 84-inch diameter pipeline for finished water (130 MGD) delivered to the Elm Fork WTP clear wells for distribution within the DWU system.

The breakdown of the supply as related to facility capacities is outlined below:

- Entire supply of 145 MGD average annual / 181 MGD with a 1.25 peaking factor (162,271 acft/yr) is conveyed from Lake Texoma to a treatment facility.
- The entire supply (including peaking) would receive conventional treatment to achieve drinking water standards, except for TDS requirements.
- Depending on the water quality at the source, up to a maximum of 50% of the source water (72.5 MGD average annual / 90.6 MGD with a 1.25 peaking factor) of the conventionally treated supply would require desalination to meet drinking water standards for TDS requirements.
- 14.5 MGD (18.1 MGD for peaking) would be discharged to the Red River as concentrate and the remaining 58 MGD (72.5 MGD for peaking) would be blended with the rest of the pre-treated supply.
- On average, a total of 130.3 MGD (146,000 acft/yr) would be conveyed to the clear wells at Elm Fork WTP. This would increase to 162.9 MGD when peaking.

A summary of DWU's portion of project and annual costs is listed in Table 7-69. Many of the DWU supply options are based on delivering raw water to the city with assumptions that the existing WTPs will be expanded. However, due to the impaired water quality at Lake Texoma, treatment costs are included in order to produce a potable supply. Therefore, the cost of a water treatment plant expansion that would be avoided by construction of the Lake Texoma Desalination strategy should be considered savings. The estimated cost saved by avoiding the construction of a WTP expansion (required for other strategies in the LRWSP) is approximated at $290 million in September 2023 dollars.

Table 7-69. Lake Texoma Project Costs

Table Units: September 2023 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Intake Pump Stations (181.1 MGD)	$196,547,000
Transmission Pipeline (30-90 in. dia., 96.7 miles)	$1,083,333,000
Transmission Pump Station(s) & Storage Tank(s)	$13,245,000
Two Water Treatment Plants (90.6 MGD and 181.1 MGD)	$1,167,105,000
Integration, Relocations, Backup Generator & Other	$6,450,000
TOTAL COST OF FACILITIES	**$2,466,680,000**
- Planning (3%)	$74,000,000
- Design (7%)	$172,668,000
- Construction Engineering (1%)	$24,667,000
Legal Assistance (2%)	$49,334,000
Fiscal Services (2%)	$49,334,000
Pipeline Contingency (15%)	$162,500,000
All Other Facilities Contingency (20%)	$276,669,000
Environmental & Archaeology Studies and Mitigation	$3,667,000
Land Acquisition and Surveying (1914 acres)	$10,693,000
Interest During Construction (3.5% for 5 years with a 0.5% ROI)	$533,612,000
TOTAL COST OF PROJECT	**$3,823,824,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$268,595,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$10,922,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$5,185,000
Water Treatment Plant	$132,404,000
Pumping Energy Costs (105818823 kW-hr @ 0.09 $/kW-hr)	$9,524,000
Purchase of Water (14,6000 acft/yr @ 31.06 $/acft)	$4,535,000
TOTAL ANNUAL COST	**$431,165,000**
Available Project Yield (acft/yr)	146,000
Annual Cost of Water ($ per acft), based on PF=1.25	$2,953
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.25	$1,113
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.25	$9.06
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.25	$3.42

7.14.4 Water Quality

Lake Texoma is a brackish water supply source that requires advanced treatment (i.e. reverse osmosis (RO) membrane treatment) to be utilized for drinking water. The Oklahoma Department of Environmental Quality identified water quality impairments for aquatic life harvesting due to oxygen depletion within the lake. In addition, portions of the lake are identified as impaired for agricultural use due to elevated chloride levels.

Water quality was summarized in a previous report prepared for DWU that explored two options for utilizing Lake Texoma water supplies. The report indicates that total dissolved solids (TDS), chloride, and sulfate concentrations exceed TCEQ drinking water standards in certain areas of Lake Texoma. TDS concentrations typically exceed the drinking water standard of 1,000 mg/L at locations nearer to the inflow of the Red River while values nearer to the dam are typically lower than the standard. The average chloride concentration at the dam is 344 mg/L, which exceeds the drinking water standard of 300 mg/L. Sulfate concentrations tend to be below the drinking water standard of 300 mg/L, but the standard is exceeded at times. Overall, water quality records indicate that TDS, chloride, and sulfate concentrations tend to be near the drinking water standards about 50 percent of the time; and therefore, the assumption was made that 50 percent of the supply will require desalination.

The report prepared for Dallas also investigated bromide concentrations in Lake Texoma because of the potential to create disinfection by-products during ozone treatment process used by the Elm Fork WTP. However, because this strategy does not consider treating Lake Texoma water at the Elm Fork WTP, bromide concentration is not a concern.

7.14.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included USFWS NWI database[70] and IPaC[71]; TPWD TXNDD[72] and county species lists[73]; and the USGS NHD[74]. Table 7-70 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of these desktop environmental factors; further desktop and field studies would need to be performed during permitting to address these potential concerns with the respective regulatory agencies.

---

[70] US Fish and Wildlife Service. (2024). National Wetlands Inventory (NWI). Retrieved from US Fish and Wildlife Service. https://www.fws.gov/program/national-wetlands-inventory

[71] US Fish and Wildlife Service. (2024). Information for Planning and Consulting (IPAC). Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[72] Texas Parks and Wildlife Department. (2024). Texas Natural Diversity Database (TXNDD). Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[73] Texas Parks and Wildlife Department. (2024). Rare, Threatened, and Endangered Species of Texas (RTEST). Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[74] US Geological Survey. (2019). National Hydrography Dataset. Retrieved from ESRI.

Since the reservoir is an existing source of water, impacts to the environment are limited to the pipeline route and associated infrastructure, changes in the levels of dissolved minerals in the river from return of the desalination concentrate, and environmental flows downstream of Lake Texoma.

A final supplemental environmental assessment completed in March 2010[75] indicated that the storage reallocation authorized by Sec 838 for 150,000 acre-feet or 300,000 acre-feet of storage would have no significant adverse effects on the natural or human environment.

7.14.5.1 HABITAT

The proposed pipelines would cover nearly 100 miles through five counties. The majority of the pipeline route follows existing road right-of-ways or crosses areas of agricultural use including crops and pasture. Impacts to preferred habitats will be minimized by utilizing these areas which have been previously disturbed where possible. Wooded riparian areas commonly occur along and adjacent to stream and river crossings that will be crossed by the pipeline corridor. Wooded areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The use of BMPs during construction activities will help to minimize potential impacts to these areas.

However, specific project components such as underground pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. As a result, any impacts to existing habitat are anticipated to be low.

7.14.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Lake Texoma project could have a medium impact on daily flows in the Red River due to the amount of supply diverted from storage that might have been previously passed downstream, especially if the reallocation of hydropower use to municipal use were to occur. If the source of the water comes from the purchase of Oklahoma's share of Lake Texoma, then impacts would likely be low.

7.14.5.3 BAYS AND ESTUARIES

The Lake Texoma project will not affect an estuary system as the Red River eventually flows into the Mississippi River system, and both river systems have large capacities of 1,889,557 acft/yr and 490,850,318 acft/yr, respectively.

7.14.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-70 represent all species federally or state listed as threatened or endangered, and federal candidate and proposed species in the counties for which the project will be located. The project area includes 22 species that meet these criteria (IPaC and county species lists). These species would need to be

---

[75] Storage Reallocation Report Lake Texoma Oklahoma and Texas, United States Army Corps of Engineers, Tulsa District, March 2010.

considered through the design process and could potentially require mitigation measures during project permitting and implementation. Siting of the pipeline to avoid specific habitat types and the use of BMPs during design and construction activities are anticipated to minimize potential impacts to species within the project area. The listed species within the project area will need to be reviewed in further detail when the design progresses in order to determine the feasibility of the project.

7.14.5.5 WETLANDS

Although a number of NWI-identified wetlands occur along the proposed pipeline corridor, flexibility in the pipeline siting would be used to minimize or avoid potential impacts to the majority of these areas. Therefore, impacts to wetlands associated with this project are anticipated to be low.

7.14.5.6 AGRICULTURAL AND NATURAL RESOURCES

Construction activities associated with the project transmission pipeline will impact an estimated 243 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils. Some agricultural activities within these areas may be disturbed during pipeline construction. However, because these areas will be allowed to return to original land uses after construction is completed; no long-term impacts to these areas are anticipated from the project. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above.

Table 7-70. Environmental Factors for Lake Texoma Desalination

Environmental Factors	Comment(s)
Habitat	Low Impact
Environmental Water Needs	Low Impact if Water is from Oklahoma's share of Texoma Medium Impact if Water is from Hydro-power Reallocation
Bays and Estuaries	Low Impact
Threatened and Endangered Species	Low to Medium Impact white-faced Ibis (ST), wood stork (ST), black rail (ST), whooping crane (SE, FE), piping plover (ST, FT), rufa red knot (ST, FT), shovelnose sturgeon (ST), paddlefish (ST), chub shiner (ST), blue sucker (ST), Red River pupfish (ST), black bear (ST), alligator snapping turtle (ST, FPT), Texas horned lizard (ST), sandbank pocketbook (ST), Louisiana pigtoe (ST), Texas heelsplitter (ST), Trinity pigtoe (ST), Texas fawnsfoot (ST), tricolored bat (FPE), monarch butterfly (C), and golden-cheeked warbler (FE)
Wetlands	Low Impact

Source: USFWS, 2024 and TPWD, 2024.

FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered.

ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened.
C = Candidate for Federal Listing.

7.14.6 Confidence and Permitting

Dallas would require a contract with some entity in Oklahoma that has permitted rights to Oklahoma's share of the yield through the Oklahoma Water Resources Board (OWRB).

The Oklahoma legislature would also need to approve this out-of-state transfer unless the contract is with a Native American tribe. However, any sale from the Native American tribes will first require a quantification of Indian water rights either by the Federal courts or as mediated by the Department of the Interior. For hydropower storage in Lake Texoma to be reallocated to municipal water supply, Federal legislation by the U.S. Congress would be needed.

Coordination with the TCEQ will be required to determine if stream standards will allow for the discharge of the concentrate into the Red River upstream of Lake Texoma. In addition, an inter-basin transfer authorization will be required from TCEQ as well as a Section 404 permit from the USACE for impacts to a waters of the U.S. from construction activities.

Previous strategies considered by Dallas included desalination of a portion of the Lake Texoma water supply and then conveying the water to Lake Ray Roberts for blending. However, the transfer of Lake Texoma water directly to other reservoirs is prohibited by the Lacey Act due to the presence of zebra mussels and therefore the current strategy delivers supplies directly to the Elm Fork WTP.

7.14.7 Flexibility and Phasing

The scale of this project limits the phasing options available to it. The project infrastructure would likely need to be sized to carry and treat the project's full supply in the initial construction. With regard to flexibility, the project has a single source of water and a single proposed discharge location, making it less flexible than many of the recommended strategies. However, the advanced treatment capabilities of the Lake Texoma Desalination strategy make it less susceptible to changes in water quality impacts than it might otherwise be. Additionally, the source of water, Lake Texoma, is a very large reservoir which would offer some buffer to the effects of drought. A final note to consider is that the Lake Texoma Strategy treats and delivers water to the DWU West subsystem, which is projected to experience large amounts of growth and require additional treatment capacity.

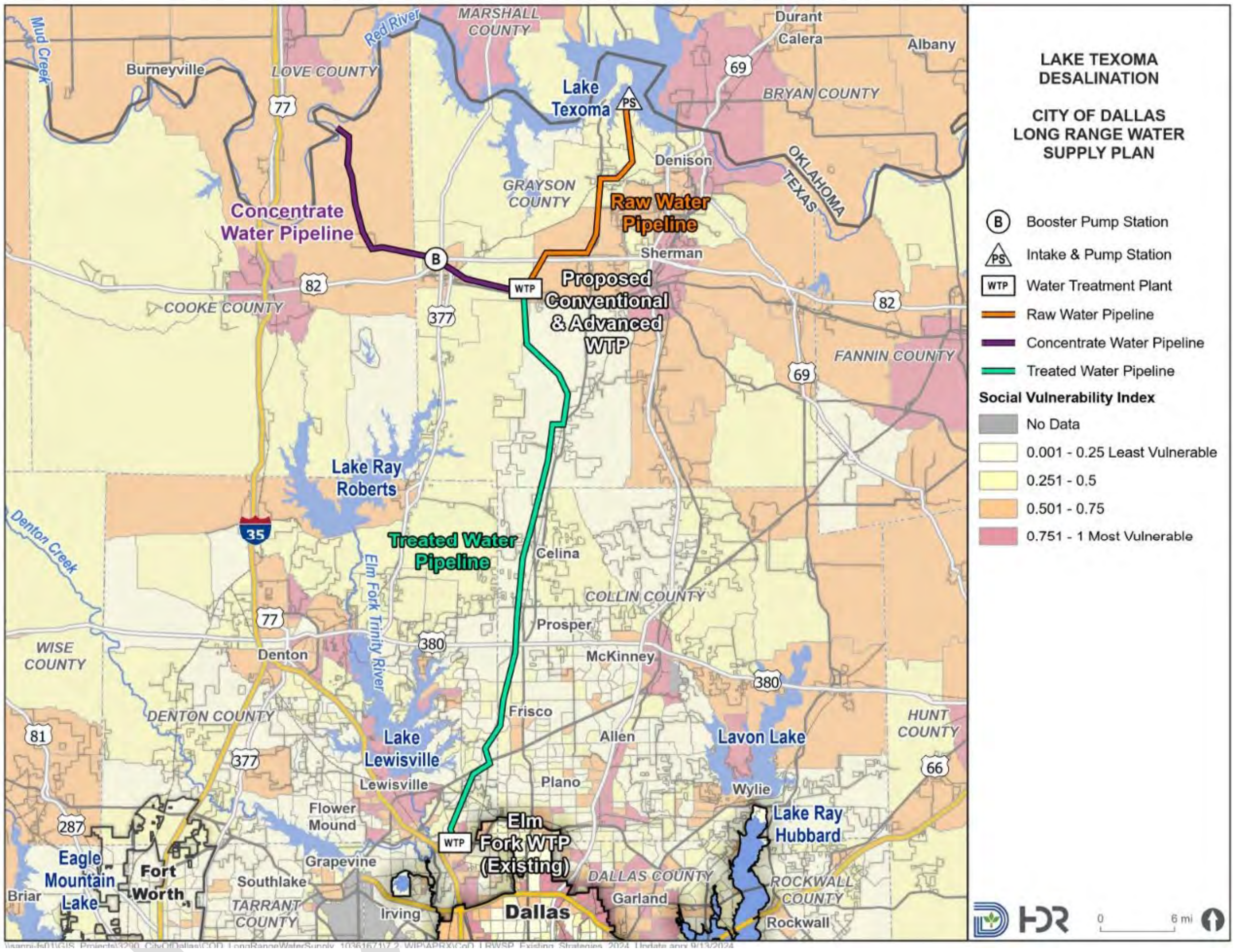
7.14.8 Equity Impacts

Impacts to equity from implementation of the Lake Texoma Desalination strategy may result from placement of potential project infrastructure such as the intake, transmission pipeline, and water treatment plant. Equity impact was evaluated by examining the percent area of project components located within each quartile of the CDC's Social Vulnerability Index. (see Table 7-23 and Figure 7-48). The project infrastructure is located in all quartiles of the CDC's SVI. The Lake Texoma intake is in the 2nd quartile, Elm Fork WTP is in the 4th quartile, and the treated water pipeline is in the 1st and 2nd quartiles. Seventy-two percent of the project is located in the 1st or 2nd quartile of the CDC's SVI, meaning that the majority of the infrastructure for this project is located outside of areas likely to experience significant equity impacts.

Table 7-71. Lake Texoma Desalination SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
38.4%	33.4%	27.9%	0.3%	3

Figure 7-48. Lake Texoma Desalination Infrastructure in Relation to the CDC's SVI



7.15 Direct Reuse

DWU has developed plans to reclaim treated wastewater and reuse this water source for direct non-potable purposes.[76] Direct reuse is the conveyance of treated effluent from a wastewater treatment facility directly to a water user via pipelines, storage tanks, and other infrastructure for beneficial use. Potential users of future direct non-potable reuse in the City includes parks, golf courses, and landscaping at multi-family residential facilities, commercial, and education facilities. Potential industrial uses of reclaimed water may include cooling water, process water, and general wash-down water.

[76] Dallas Water Utilities. Dallas Reclaimed Water Delivery System Feasibility Study, HDR 2013

The City currently owns and operates one direct non-potable reclaimed water system known as the Cedar Crest Pipeline which delivers reclaimed water to multiple customers in the Cedar Crest Service Area. In addition, the City has evaluated proposed projects that could provide additional recycled water to the nearby downtown area.

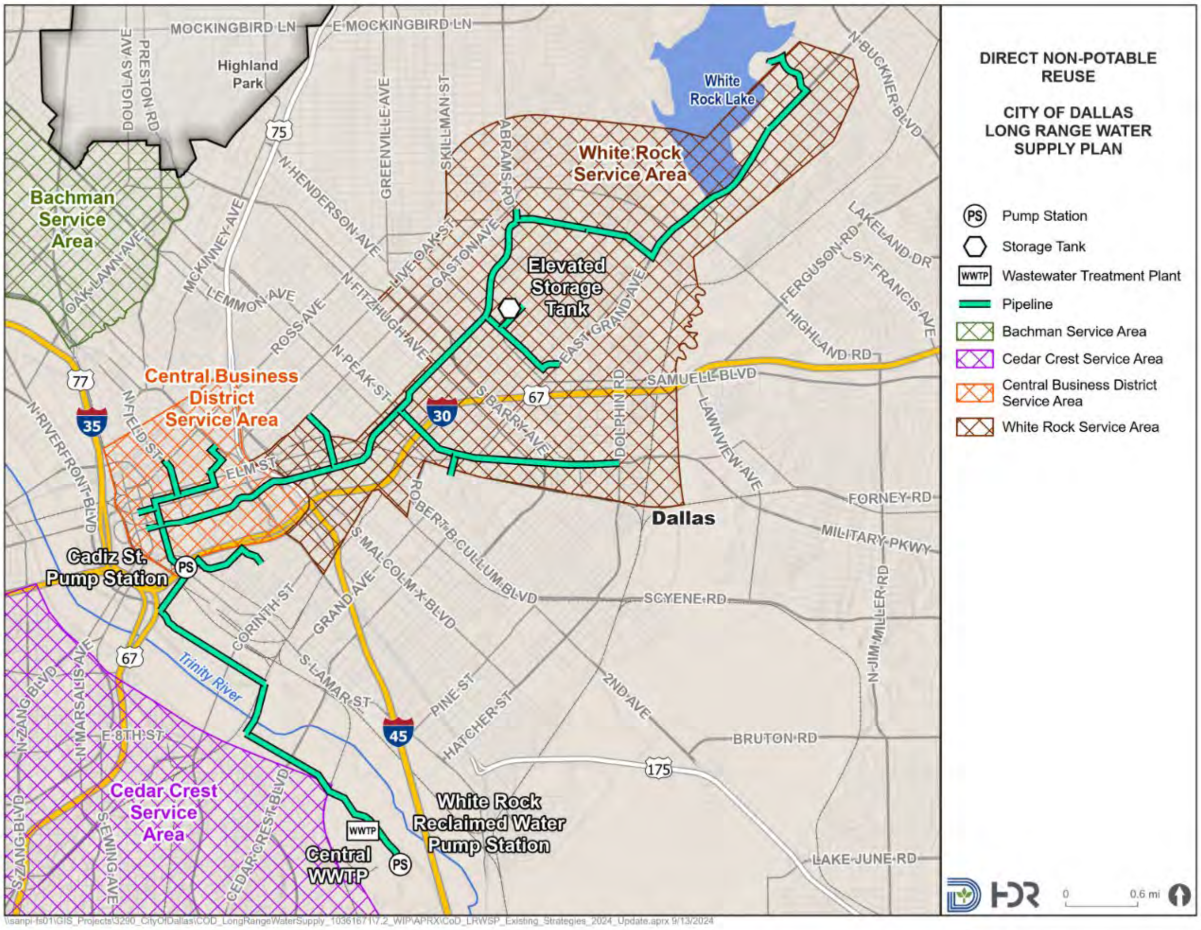
7.15.1 Strategy Description

The Direct Non-potable Reuse Project includes providing reclaimed water from Dallas' Central Wastewater Treatment Plant (CWWTP) to both the Central Business District (CBD) and the White Rock Service Areas (Figure 7-49). The system layout maximizes potential customers and associated demands for reclaimed water. Demands are estimated at 2.23 MGD with a 3.0 peaking factor. The CBD Service Area, generally known as Downtown Dallas, is the area bounded to the north by Woodall Rodgers Parkway, to the south by I-30, and the west and east by I-35 and US 75, respectively. Potential reclaimed water users in this area include a number of hotels, office buildings, city parks, and commercial developments. The White Rock Service Area includes the area from White Rock Lake to the CBD. This strategy was identified in a Title XVI U.S. Bureau of Reclamation (USBuRec) study performed during the development of the 2014 LRWSP. Potential reclaimed water users developed at that time in this area include the Dallas Arboretum, Lakewood Towers, Baylor Healthcare, Lakewood Country Club, Schepps, Fair Park, Randall Park, and Samuel Grand Park. This customer set would need to be reevaluated before this project could be implemented.

Recycled water from the CWWTP will be pumped from a proposed White Rock Reclaimed Water Pump Station through an existing 60-inch forcemain which will require some improvements. The existing forcemain terminates at the Cadiz Street Pump Station where a connection will be made to the CBD Service Area Pipeline. Currently, this force main is still in service delivering effluent to the CWWTP. Wastewater system improvements would be needed before this project could be implemented. This write up describes the project identified from the USBuRec study and does not include updates to the wastewater system.

To serve the CBD area, a connection to the existing 60-inch line at Cadiz Street Pump Station would be made. Nearly 12 miles of new reclaimed water pipeline will be required. In addition, a 500,000-gallon elevated storage tank will be required to sustain system pressures.

Figure 7-49. Direct Non-Potable Reuse



7.15.2 Water Availability

DWU owns and operates two WWTPs that serve the City of Dallas and eleven wholesale wastewater customer cities. The CWWTP is permitted to produce Type I and Type II reclaimed water and is located on the west bank of the Elm Fork of the Trinity River, four miles south of downtown. The annual average flow permitted capacity of CWWTP is 133.3 MGD and the permitted peak-hour flow is 400 MGD. No water right from the state is needed for direct reuse projects.

7.15.3 Project Cost Estimate

Required infrastructure will include 12 miles of new reclaimed water pipeline, construction costs to slip line the existing 60-inch diameter forcemain, a new pump station, and an elevated storage tank. The new pump station would consist of three vertical turbine pumps discharging into a common header connected to the slip lined 54-inch forcemain.

A summary of project and annual costs for the Direct Non-Potable Reuse strategy is listed in Table 7-72. Total project costs are $51 million. Considering that up to 25% of the project could be funded by the Bureau of Reclamation, Dallas' portion of the total project cost is $36 million. Dallas annual costs for the project assume a 20-year debt service with a 3.5 percent interest rate and delivery of 2.2 MGD are estimated to be $3,037,000 per year. The unit cost of water for this project would be about $1,215 per acft or $3.73 per 1,000 gallons. After debt service is retired, the unit cost of water is decreased to $200per acft or $0.61 per 1,000 gallons. Also, this costing strategy assumes that Dallas already owns the land and right-of-way necessary for the project.

Without the 25% funding from the Bureau of Reclamation, the project costs would increase by $12,014,000. This change results in a unit cost of $1,553 per acft ($4.77 per 1,000 gal), a 27.8 percent increase. Costs after debt service is paid for would not be changed.

Table 7-72. Cost Estimate Summary for Direct Non-Potable Reuse

Table units: September 2023 dollars

Item	Estimated Cost for Facilities [a]
CAPITAL COST	
Mobilization	$1,665,000
Transmission Pipeline (12 miles of 4 – 24 in dia. PVC)	$11,517,000
Transmission Pipeline (30 in dia., 54 in dia., Slipline Pipe)	$15,257,000
Transmission Pump Station	$4,807,000
Elevated Storage Tank	$2,221,000
TOTAL COST OF FACILITIES	**$35,467,000**
OTHER PROJECT COSTS	
Engineering, Bidding, Geotech, Construction Services, Survey, Bonds and Insurance, and Contingencies	$12,588,000
Bureau of Reclamation Funding (25% of total project cost)	**($12,014,000)**
TOTAL COST OF PROJECT	**$36,041,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$2,536,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$427,000
Pumping Energy Costs (kW-hr @ 0.09 $/kW-hr)	$74,000
TOTAL ANNUAL COST	**$3,037,000**
Available Project Yield (acft/yr)	**2,501**
Annual Cost of Water ($ per acft)	**$1,215**
Annual Cost of Water ($ per 1,000 gallons)	**$3.73**
Annual Cost of Water after Debt Service ($ per acft)	**$200**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.61**

[a] Costs obtained from the December 2013 DWU Feasibility Study and updated to September 2023 dollars using the Engineering News-Record's construction cost index and are not based on the TWDB costing tool.

7.15.4 Water Quality

Since this strategy will provide non-potable water to customers with demands that do not require potable water, there are no drinking water concerns. DWU is permitted to produce Type I and Type II reclaimed water. Type I reclaimed water is suitable for areas where public contact is likely, for example, irrigation of public parks or golf courses. Reclaimed water systems are monitored by and require approval by the TCEQ to assure compliance with water quality standards. The direct non-potable water system will be delivered to reclaimed water customers through a separate distribution system and will not come in contact with treated potable water.

7.15.5 Environmental Impacts

A preliminary desktop review of publicly available data was conducted which included UUSFWS NWI database and IPaC[77]; TPWD TXNDD[78] and county species lists[79]; and the USGS NHD[80]. Table 7-49 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of desktop environmental factors; further desktop and field studies would need to be performed during permitting to address these potential concerns with the respective regulatory agencies.

7.15.5.1 HABITAT

The project area is within a highly urbanized area. Wooded areas may occur in riparian areas along and adjacent to the Trinity River and White Rock Creek tributary. It is unlikely that this project would adversely affect any unique habitats in Dallas County.

7.15.5.2 ENVIRONMENTAL WATER NEEDS

Implementation and operation of the Direct Non-Potable Reuse Project does not require any TCEQ water right permitting actions.

7.15.5.3 BAYS AND ESTUARIES

The Direct Non-Potable Reuse Project relies on the use of water from White Rock Lake with pipeline crossings at the White Rock Creek tributary and the Trinity River. It should have very limited effects on freshwater inflow to the Trinity Bay because it is reused water.

7.15.5.4 THREATENED AND ENDANGERED SPECIES

The species included in Table 7-49 represent all species federally or state listed as threatened or endangered, and federal candidate and proposed species in the county for which the project will be located. The project area includes 16 species that meet these criteria (county species list and IPaC). These species would need to be considered through the design process and could potentially require mitigation measures during project permitting and implementation. However, due to the limited amount of disturbance associated with this project and the disturbed nature of the habitat within the project area, minor impacts to listed species are anticipated. The listed species within the project area will need to be reviewed in further detail when the design progresses in

---

[77] US Fish and Wildlife Service. (2024). *Information for Planning and Consulting (IPAC)*. Retrieved from US Fish and Wildlife Service: https://ipac.ecosphere.fws.gov/

[78] Texas Parks and Wildlife Department. (2024). *Texas Natural Diversity Database (TXNDD)*. Retrieved from TPWD: https://tpwd.texas.gov/huntwild/wild/wildlife/wildlife_diversity/txndd/

[79] Texas Parks and Wildlife Department. (2024). *Rare, Threatened, and Endangered Species of Texas (RTEST)*. Retrieved from TPWD: https://tpwd.texas.gov/gis/rtest/

[80] US Geological Survey. (2019). *National Hydrography Dataset*. Retrieved from ESRI.

order to determine the feasibility of the project. There is no USFWS designated critical habitat located within the vicinity of the project.

7.15.5.5 WETLANDS

Although several NWI-mapped wetlands occur along the proposed pipeline corridors, flexibility in the pipeline siting could be used to minimize or avoid potential impacts to many of these areas.

7.15.5.6 AGRICULTURAL AND NATURAL RESOURCES

The project will not impact any prime farmland in Dallas County. This strategy is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources. Impacts to natural resources of the state are included in the Environmental Impacts section above.

Table 7-73. Environmental Factors for the Direct Non-Potable Reuse Project

Environmental Factors	Comment(s)
Habitat	Area highly urbanized. Low Impact
Environmental Water Needs	Low Impact
Bays and Estuaries	Low Impact
Threatened and Endangered Species	White-faced ibis (ST), wood stork (ST), black rail (ST), whooping crane (SE, FE), rufa red knot (ST, FT), alligator snapping turtle (ST, FPT), Texas horned lizard (ST), sandbank pocketbook (ST), Louisiana pigtoe (ST), Texas heelsplitter (ST, FPT), Trinity pigtoe (ST), Texas fawnsfoot (ST, FT), golden-cheeked warbler (FE), monarch butterfly (C), and tricolored bat (FPE). Low to Medium Impact
Wetlands	Low Impact
Agricultural and Natural Resources	No Impact

Source: USFWS, 2024 and TPWD 2024
FE = Federally Listed as Endangered. FT = Federally Listed as Threatened. SE = State Listed as Endangered. ST = State Listed as Threatened. FPE = Federally Proposed Endangered. FPT = Federally Proposed Threatened. C = Candidate for Federal Listing.

7.15.6 Confidence and Permitting

The CWWTP is permitted to produce Type I and Type II reclaimed water and is permitted by TCEQ to convey and distribute reclaimed water to its customers (Authorization No. R 10060-001). Reclaimed water facilities must be designed and constructed in accordance with TCEQ criteria and monitored so as to assure compliance with water quality standards, to promote beneficial use of reclaimed water, and to provide adequate notice to users and the public. Reclaimed water permits also require approval of facilities, and of contracts for beneficial use between the users and the providers.

Additionally, any impacts within waters of the U.S. will need to be considered in the Section 404 permitting process. The potential permitting requirements are shown in Table 7-74.

Table 7-74. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
210	TCEQ	Required to reuse domestic wastewater.
Section 404	USACE	Required for construction activities in waters of the U.S.

7.15.7 Flexibility and Phasing

As with any project, there are inherent risks to eventual implementation and development. These risks can include permitting risks, mitigation risks, performance risks, and/or risks associated with various types of conflict. The Direct Non-Potable Reuse Project is susceptible to performance risks associated with public perception affecting customer demand for project and distribution system challenges.

The proposed service areas are all highly developed areas which will create challenges getting easements and will create impacts to business and street traffic during construction. The CBD, in general, will be difficult and expensive for utility construction and careful consideration of feasibility and the demand for reclaimed water in downtown should be made before making the commitment to invest in infrastructure to deliver reclaimed water to the area. Flexibility of this strategy is limited with use of the existing 60-in forcemain. Project infrastructure and routing will be based on the existing forcemain.

Only non-potable customer demands within the City of Dallas were evaluated; therefore, no project partnerships were considered at this time. Should it be determined that there is demand outside of Dallas' retail service area, this project could be reevaluated for inclusion of other entities.

7.15.8 Equity Impacts

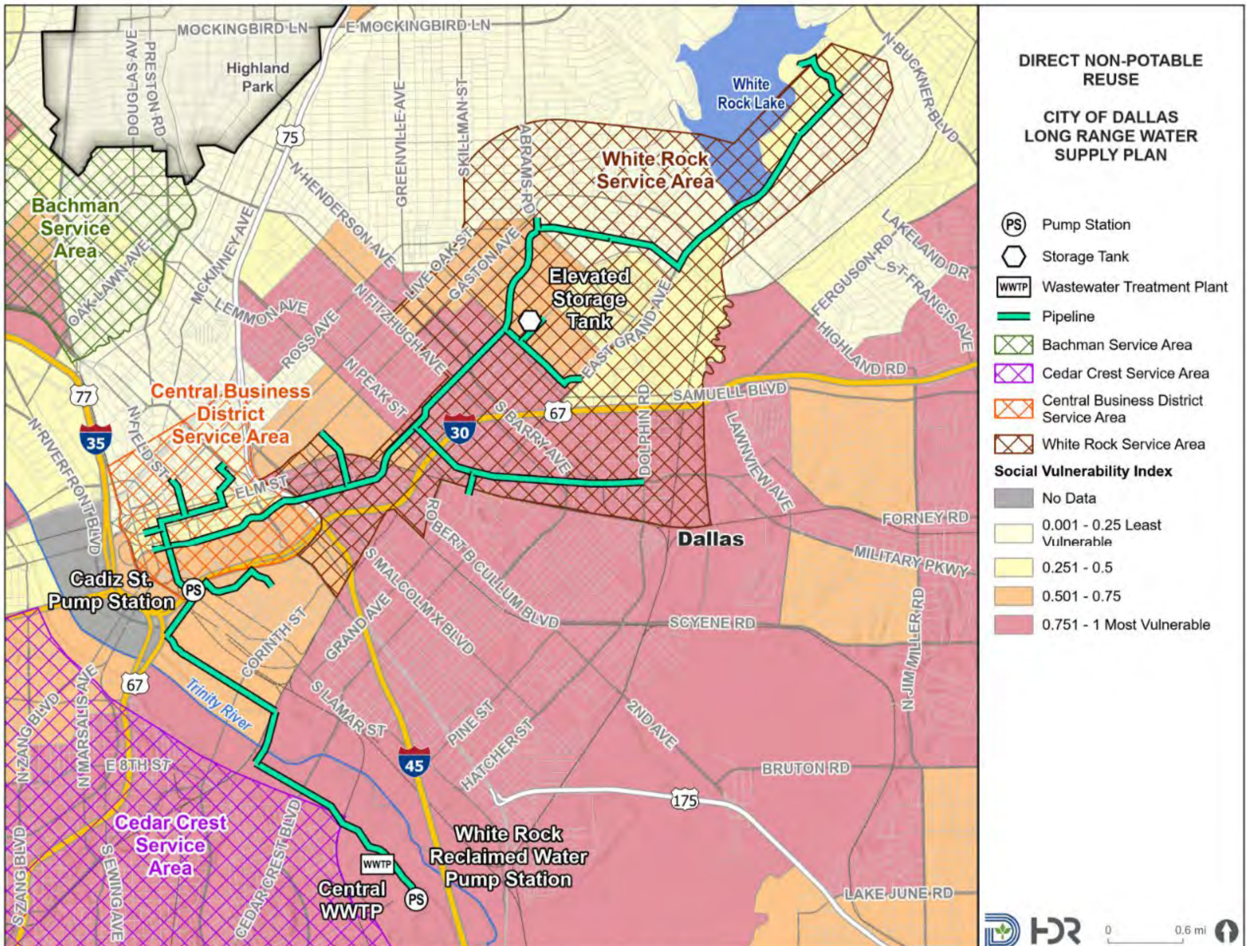
Impacts to equity from implementation of the Direct Non-Potable Reuse strategy may result from development of the transmission pipeline, pump station, and elevated storage tank.

Equity was evaluated by looking at the amount of area per quartile where project components are proposed to be located. The land area required for the reservoir and pipeline were combined and the results are displayed as the percentage of project area located in each quartile, shown in Table 7-75. A visual representation of the quartile distribution is shown in Figure 7-50.

Table 7-75. Direct Non-Potable Reuse SVI Quartile Distribution

Equity Score				
1st quartile (low) less vulnerable	2nd quartile	3rd quartile	4th quartile (high) highly vulnerable	Value
15.3%	14.3%	33.8%	36.6%	**2**

Figure 7-50. Direct Non-Potable Reuse Project Footprint with SVI Visual



Based on the results, over 60% of the project area is projected to reside in areas with an increased vulnerability to equity impacts. The large distribution of project area residing in the 3rd and 4th quartile indicates that communities in these areas are likely to experience greater equity impacts than communities in the 1st or 2nd quartiles. This project is scored as a 2 based on the equity criteria scoring guidelines.

The scoring and quartile distribution indicates that this project may have some negative impacts to socially vulnerable communities and may slightly increase inequity to said communities. Moderate mitigation for implementation of this strategy would be necessary to reduce the burden on socially vulnerable communities.

7.15.9 Direct Potable Reuse

An alternative reuse strategy to consider is a direct potable reuse project. A direct potable reuse project would involve reclaiming the treated wastewater effluent at the wastewater treatment plant and delivering it directly to a water treatment plant with advanced water treatment capabilities. After advanced water treatment, the water can then be delivered directly to potable water customers. Developing direct potable reuse as a water supply strategy would provide Dallas with a water supply that is resilient to drought and increasing air temperatures. It is assumed that a direct potable reuse project could supply approximately 102 MGD since Dallas has water rights to both the Central and Southside Wastewater Treatment Plants return flows.

TCEQ permitting requirements would be more involved and the environmental impacts previously discussed would be similar. Public outreach and education efforts would likely be necessary to gain public acceptance of a direct potable reuse project.

The facilities required for a direct potable reuse project include a 90-inch transmission pipeline from one of Dallas' wastewater treatment plants to one of the water treatment plants. Improvements would need to be made to the water treatment plant, including a 102 MGD WTP expansion and a 102 MGD advanced water treatment plant facility. The total cost of this project would be just under 2 billion dollars with an annual cost of 235 million dollars. The unit cost of water would be $2,055 per acft or $6.30 per 1,000 gallons.

Further evaluation on the potential feasibility of this alignment should be conducted. This strategy would directly impact the ability to develop the main stem balancing reservoir which is an indirect reuse strategy as both projects rely on the same source. Direct reuse is becoming more prevalent in the industry, but the general public has not accepted such a large-scale direct potable reuse project at this time. Significant public education and acceptance would need to be achieved before further implementation.

7.16 Stormwater Supplies

Stormwater managements techniques that can double as a water supply are becoming increasingly popular for cities with compatible infrastructure. The development of the 2024 LRWSP included research into cities similar to the City of Dallas to find examples of feasible stormwater-capture water supply strategies in use in the industry today. A review of Dallas' stormwater system infrastructure was performed in an attempt to identify water supply potential. The 2024 LRWSP provides no recommended stormwater strategies that can provide water supply benefits but offers a brief description of possible avenues for future evaluation in subsequent planning efforts.

7.16.1 Strategy Description

Traditional stormwater projects are utilized to mitigate the damaging impacts of large rain events and the resulting flooding impacts. This is the norm for cities across the country, it is no different for Dallas. The City of Dallas utilizes stormwater infrastructure to move stormwater runoff away from areas susceptible to flooding with emphasis on moving water away from areas as fast as possible. Stormwater is traditionally viewed as a dangerous nuisance, not as a potential source of water supply. However, cities are viewing stormwater in a positive way to meet water supply needs in certain applications. There are many approaches to managing stormwater that are being implemented in major cities across the nation. These approaches range from utilizing site specific uses such as retention ponds for use in flood reduction and non-potable irrigation in parks, groundwater recharge, and tunnels utilized to accommodate large stormwater events with benefits to streamflow mitigation and irrigation among others.

In a review of Dallas' stormwater system, there are a couple of opportunities to potentially utilize stored stormwater to meet non-potable needs within their project locations. Cole Park is an existing underground stormwater storage facility that has a 71 million gallon storage capacity. The facility is located underneath the park owned by the City. Although the facility was designed to capture stormwater to mitigate flooding and ultimately move the water to the Trinity River, there could be a potential to utilize a portion of the stored water to irrigate the park reducing potable water demand. The second large scale facility is the Mill Creek tunnel that is currently under construction with the designed capacity to move 9 million gallons per minute of flow over a 5 plus mile route. The Mill Creek tunnel crosses multiple parks including Fair Park and Buckner Park, both could be candidates for using water from the tunnel to irrigate areas within the parks reducing demand on the potable system. These are two potential opportunities that need to be further analyzed to determine the potential options to offset potable uses. As the City moves forward with their stormwater planning, there is potential to utilize the City's 410 parks with over 21,000 acres to co-locate a stormwater facility to provide mutual benefits of reducing stormwater runoff and benefiting the park by providing non-potable water for irrigation. Challenges with non-potable use of stormwater include the possibility that some type of treatment would still be necessary. Significant infrastructure investment into a source that is not reliable and could require use of potable infrastructure as well as investment into new infrastructure. Current stormwater infrastructure is designed to slow down and mitigate flooding or transfer stormwater to natural water courses to avoiding flooding populated areas. Conversion of these facilities for non-potable water supply could result in reduction of the anticipated stormwater benefits.

7.17 Riverbank Filtration

HDR was tasked with providing a preliminary assessment of the potential for riverbank filtration as an alternative to surface water intakes at three DWU off channel reservoir projects: Red River Off-Channel Reservoir, Main Stem Balancing Reservoir, and Sabine Conjunctive Use Project. The surficial geology and the estimated potential supply available through riverbank filtration at each project site are described below.

7.17.1 Red River Off-Channel Reservoir

The Red River Off-Channel Reservoir (OCR) project involves pumping water from the Red River at Arthur City, Texas to three OCRs in series that will be used for sediment settling, water quality improvement, and storage. An average of about 102 MGD will be transported from the third OCR via an 84-inch transmission pipeline to Lake Ray Roberts for use by Dallas. The purpose of this evaluation is to determine if a riverbank filtration system can be utilized to ultimately supply 102 MGD from the Red River.

7.17.1.1 HYDROGEOLOGIC CHARACTERISTICS

The surficial geology within 0.5 miles of the river intake point of the Red River Off-Channel Reservoir project is the Quaternary Alluvium. The alluvium consists of sand, gravel, and clay. Information on the depth and composition of the alluvium at the intake point was sourced from the Texas Water Development Board (TWDB) Groundwater Database. Reports for State Wells 1814902, 1822201, and 1822306 contained well information that included well depth, water level, and aquifer test results. These hydrogeologic parameters are summarized in Table 7-76 and were used to estimate the supply capacity for a potential riverbank filtration wellfield system at the river intake point.

Table 7-76. Hydrogeologic parameters sourced from TWDB state wells in the Red River alluvium.

State Well Number	1814902	1822201	1822306
Well Depth (feet)	53	56	70
Water Level (feet below ground surface (bgs))	19	20	12.5
Pumping Rate (gpm)	320	350	480
Drawdown (feet)	31	30	56
Specific Capacity (gpm/ft)	10.3	11.7	8.6
Screen interval (feet bgs)	-	48 - 56	40-53

7.17.1.2 METHODOLOGY

A Theis analysis was conducted to estimate the number of vertical wells required to sustainably produce the target diversion rate given the hydrogeologic data listed in Table 7-76.[81] The methodology assumes a confined aquifer of infinite aerial extent, so the maximum drawdown was set to prevent dewatering of the well screen and the related reduction in aquifer transmissivity. Based on information from Wells 1822201 and 1822306, the maximum drawdown was set to 31.75 feet. The average saturated thickness and average hydraulic conductivity of the three wells was used to estimate the aquifer transmissivity at 2,236 ft^2/day. Since there was no information on aquifer storativity, a value of 0.001 was assumed based on professional judgement.

[81] Theis, C.V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage: Transactions of the American Geophysical Union, v. 16, p. 519-524.

The impact of the riverbed as a source of recharge was incorporated into the analysis using image wells. This approach assumes a recharge well is paired with each production well. The recharge well is located at a distance twice that of the distance from the production well to the riverbank and is recharged at the same rate as the production well withdrawal. The corresponding mounding was reduced by one foot to account for head loss through riverbed sediments. Impacts were estimated at 30 days given the proximity of the recharge source would cause water levels to stabilize relatively quickly.

One set of adjacent wells (production and recharge wells) were included in the simulation. To simplify the analysis, the net withdrawal was used for the adjacent production wells. The net withdrawal was computed as the ratio of the net drawdown (drawdown minus mounding) to drawdown times the proposed withdrawal rate.

7.17.1.3 RESULTS

Based on the Theis analysis, alluvial wells spaced 300 feet apart and 150 feet from the riverbank can sustainably yield 180,011 gallons per day per well. Developing a riverbank filtration system to obtain 102 MGD of supply capacity would require 567 wells or 31.2 linear miles of wellfield and would therefore not be feasible.

7.17.2 Main Stem Balancing Reservoir – Trinity River Basin

The main stem balancing reservoir is an indirect potable reuse (IPR) project that will provide Dallas with a strategy to utilize its previously permitted return flows.

Dallas currently has a water right permit to divert and use up to 220.5 MGD of its effluent discharged from its Central and Southside WWTPs. This strategy involves building a large storage reservoir (about 300,000 AF) below the confluence of the East Fork and the main stem of the Trinity River to store Dallas' return flows which would provide both storage and natural treatment until it is needed for supply. The water diverted into the OCR would be delivered back to one of Dallas' WTPs or swapped with another entity for an alternative supply. Dallas anticipates the supply from the Main Stem Balancing Reservoir to be as much as 102.

7.17.2.1 HYDROGELOGIC CHARACTERISTICS

The Quaternary Alluvium is the surficial unit at the Main Stem Balancing Reservoir river intake point and it includes indistinct low terrace deposits, gravel, sand, silt, and organic matter. The hydrogeologic parameters sourced from TWDB state well reports for alluvial wells along the Trinity River are summarized in Table 7-77. The wells listed in Table 7-77 have a lower pumping rate and specific capacity in comparison to alluvial wells along the Red River.

Table 7-77. Hydrogeologic parameters sourced from TWDB state wells reports in the Trinity River alluvium.

State Well Number	325680	341288	354673
Well Depth (feet)	35	37	60
Water Level (feet bgs)	23	29	20
Pumping Rate (gpm)	38	30	14
Drawdown (feet)	6	3	50
Specific Capacity (gpm/ft)	6.3	10	0.3
Screen interval (feet bgs)	25 - 35	27 - 37	20 - 60

7.17.2.2 RESULTS

The analytical approach used for the Red River OCR riverbank filtration evaluation was used to evaluate the available capacity from a riverbank filtration system at the Trinity River intake point. As a result, alluvial wells spaced 300 feet apart and 150 feet from the riverbank can only sustainably yield 1,152 gallons per day per well. An infeasible number of wells and land would be needed to obtain a firm yield of 102 MGD from a riverbank filtration system at this site due to a low well production rate. A riverbank filtration system along the Trinity River is not recommended as a source for the Main Stem Balancing Reservoir project.

7.17.3 Sabine Conjunctive Use Project

The Sabine conjunctive use project combines groundwater supplies from the Carrizo-Wilcox Groundwater project with an OCR in Smith County that impounds surface water diverted from the Sabine River. The supplies from the OCR and wellfields are delivered to the Lake Fork pump station and then DWU's Eastside WTP via pipeline. The anticipated supply from the conjunctive use project is estimated to provide a firm yield of 93 MGD.

7.17.3.1 HYDROGEOLOGIC CHARACTERISTICS

The surficial geology within 0.5 miles of the river intake point of the Sabine River OCR project is the Quaternary Alluvium. Two TWDB state well reports within the alluvium were identified near the river intake point (Table 7-78). Both wells have a low pumping rate and specific capacity in comparison to the Red River wells identified in Table 1, indicating that a well system at this site will likely not provide a sustainable supply yield.

Table 7-78. Hydrogeologic parameters sourced from TWDB state wells reports in the Sabine River alluvium.

State Well Number	3432404	172951
Well Depth (feet)	60	48
Water Level (feet bgs)	20	12
Pumping Rate (gpm)	35	20
Drawdown (feet)	30	10
Specific Capacity (gpm/ft)	1.17	2
Screen interval (feet bgs)	25 - 49	22 - 42

7.17.3.2 RESULTS

The analytical approach used for the Red River OCR and Main Stem Balancing Reservoir riverbank filtration evaluations was applied to estimate the available capacity from a riverbank filtration system at the Sabine River intake point. As a result, alluvial wells spaced 300 feet apart and 150 feet from the riverbank can only sustainably yield 2,880 gallons per day per well. Due to a low production rate, an infeasible number of wells and land would be needed to obtain a firm yield of 93 MGD from a riverbank filtration system at this site. A riverbank filtration system is not recommended as a source for the Sabine Conjunctive Use Project.

This Page Intentionally Blank.

8 Infrastructure Constraints and Capital Improvement Plan

This section summarizes water production capacity needs based on updated water demand projections to 2080, and the recommended water supply strategies as discussed in Chapters 6 and 7. The summary enumerates infrastructure constraints and presents figures showing the timeline for supply / capacity driven improvements. This section also highlights the resulting capital improvement plan (CIP) implications.

8.1 Water Production Facilities

Since developing the 2014 LRWSP, Dallas Water Utilities (DWU) completed the Water Production Facilities Strategic Plan (WPFSP) in 2024. The WPFSP included several assessments focused on identifying performance limiting factors (PLFs) and capacity limiting factors (CLFs) at the water production facilities, namely Dallas' three water treatment plants: Elm Fork WTP, Bachman WTP, and the East Side WTP. Assessments included evaluation of treatment process performance, asset condition, and other support systems and resources. Outcomes included greater understanding of the reliable production capacity of the treatment plants relative to the published, rated capacity and the source of the CLFs.

Another objective for the WPFSP was to develop a CIP process workflow and a clear and transparent project prioritization methodology. Key outcomes from the WPFSP included adoption of a stepwise CIP process workflow, prioritization methodology, and a 10-year CIP with a 30-year outlay. DWU implemented the new approach in developing its CIP in March 2023 and completed the process workflow cycle for the first time to update the CIP in March 2024. The CIP prioritization is based on project scoring using weighted criteria and a defined scoring system. While the highest scoring projects are generally higher in the prioritization, the process accounts for other factors such as capacity and / or regulatory triggers to create "no later than" dates for critical capacity and / or regulatory driven projects.

The 2024 LRWSP and the content in this section relies on the work contained in the WPFSP and does not modify the analysis or recommendations contained therein. Rather, the content in this section builds on the WPFSP effort as a foundation on which to overlay the recommended water supply plan for DWU. This section achieves that overlay by identifying areas where implementation of new water management strategies impacts the timing of improvements to DWU's water production facilities as compared to WPFSP outcomes and the March 2024 CIP. This includes implications for raw water infrastructure and water distribution.

By identifying infrastructure constraints and required water production improvements, DWU will have greater understanding of the CIP planning necessary to recognize the cost of new water supply strategy implementation.

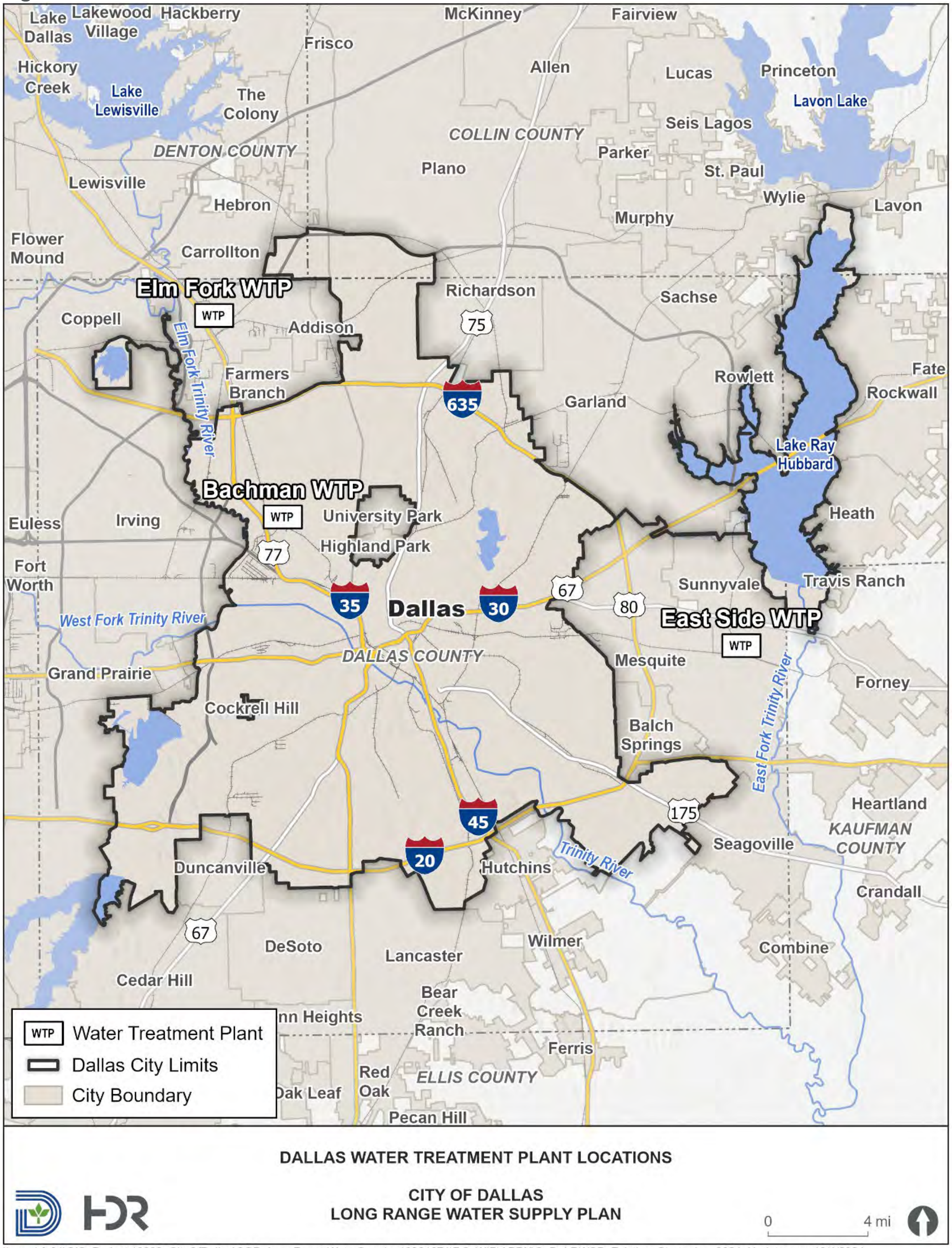
8.2 Existing Water Treatment Plants

DWU currently operates the Elm Fork, Bachman, and East Side WTPs, all surface water treatment plants that use conventional treatment processes with raw water ozonation and chloramines as the residual disinfectant in the distribution system. Figure 8-1shows the locations of the three water treatment plants.

DWU recently completed the Water Quality Improvements (WQI) Program at the Bachman and East Side WTPs to enhance the chemical and biological stability of the treated water, with noticeable benefits in addressing historical water quality challenges in the distribution system. The improvements included a process transition from partial lime softening to an enhanced organics removal strategy that includes biologically active filtration (BAF). The WQI Program is ongoing at the Elm Fork WTP with planned construction of new treatment trains and a filter complex designed for BAF.

The sections that follow provide a brief introduction to the plants. The WPFSP includes detailed descriptions of each WTP and the treatment process, with summaries of the plant design characteristics.

Figure 8-1. Dallas Water Treatment Plant Locations



\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 10/1/2024

8.2.1 Bachman WTP

Figure 8-2 provides an aerial view of the Bachman WTP. The plant is bound on all sides by existing development and Bachman Lake. While there is limited site space, the WPFSP presents concepts for significant improvements at the plant to address aging infrastructure, including sequenced construction of new, smaller footprint plate settler treatment trains with new filter stages. The site plan concept creates provisions to incorporate additional treatment technology, whether needed to address water quality changes from future water supply integration or regulatory requirements (e.g., PFAS). The concept also lends to the potential for achieving additional production capacity from the Bachman WTP in the future. For a graphic depiction of the future concept, refer to the Bachman WTP CIP Summary Map included in the WPFSP.

Figure 8-2. Aerial View of the Bachman WTP

8.2.2 Elm Fork WTP

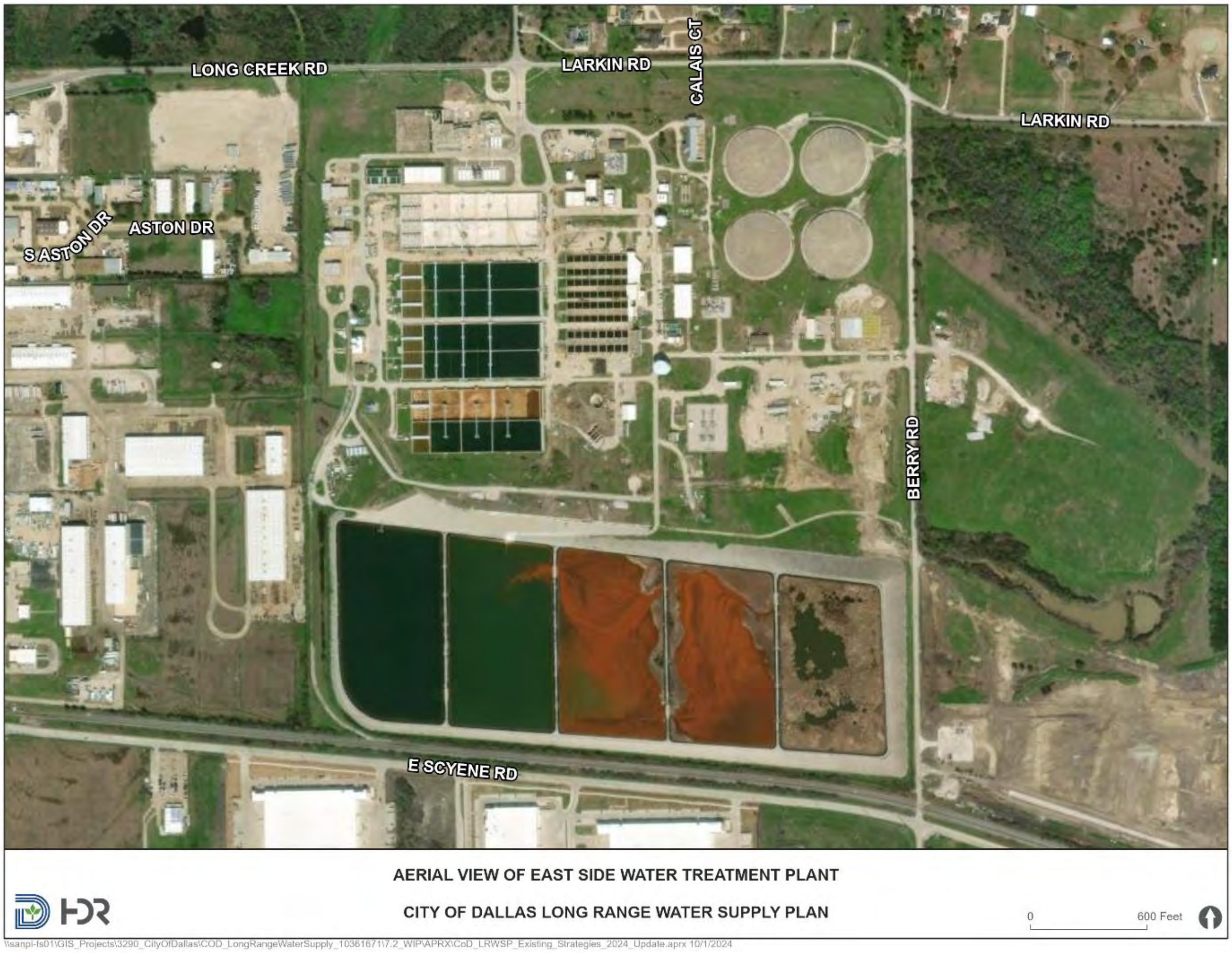
Figure 8-3 provides an aerial view of the Elm Fork WTP. While there is limited site space at the Elm Fork WTP, the WPFSP presents current concepts for implementing the planned WQI program. The improvements will replace aging infrastructure while incorporating the process transition to enhanced organics removal with BAF. The existing treatment trains will be replaced with new, smaller footprint plate settler treatment trains and the new BAF complex, located within the footprint of the on-site residuals lagoons (north of the existing treatment trains). Like the Bachman WTP concept, the Elm Fork WTP site plan concept creates provisions to incorporate additional treatment technology if needed in the future. The concept also accounts for potential plant capacity expansion in the future. For a graphic depiction of the future concept, refer to the Elm Fork WTP CIP Summary Map included in the WPFSP.

Figure 8-3. Aerial View of the Elm Fork WTP

8.2.3 East Side WTP

Figure 8-4 provides an aerial view of the East Side WTP. DWU has completed significant, recent improvements at the plant associated with the WQI program. The site and facilities are designed to accommodate completing an expansion to 540 million gallons per day (MGD) of capacity. The WPFSP also established a site plan concept for the East Side WTP, with provisions for replacing aging pumping facilities while incorporating additional treatment technology if needed. Concepts also consider the potential for achieving additional production capacity from the plant, beyond 540 MGD, if needed in the future. For a graphic depiction of the future concept, refer to the Bachman WTP CIP Summary Map included in the WPFSP.

Figure 8-4. Aerial View of the East Side WTP



8.2.4 Treated Water Service Customers

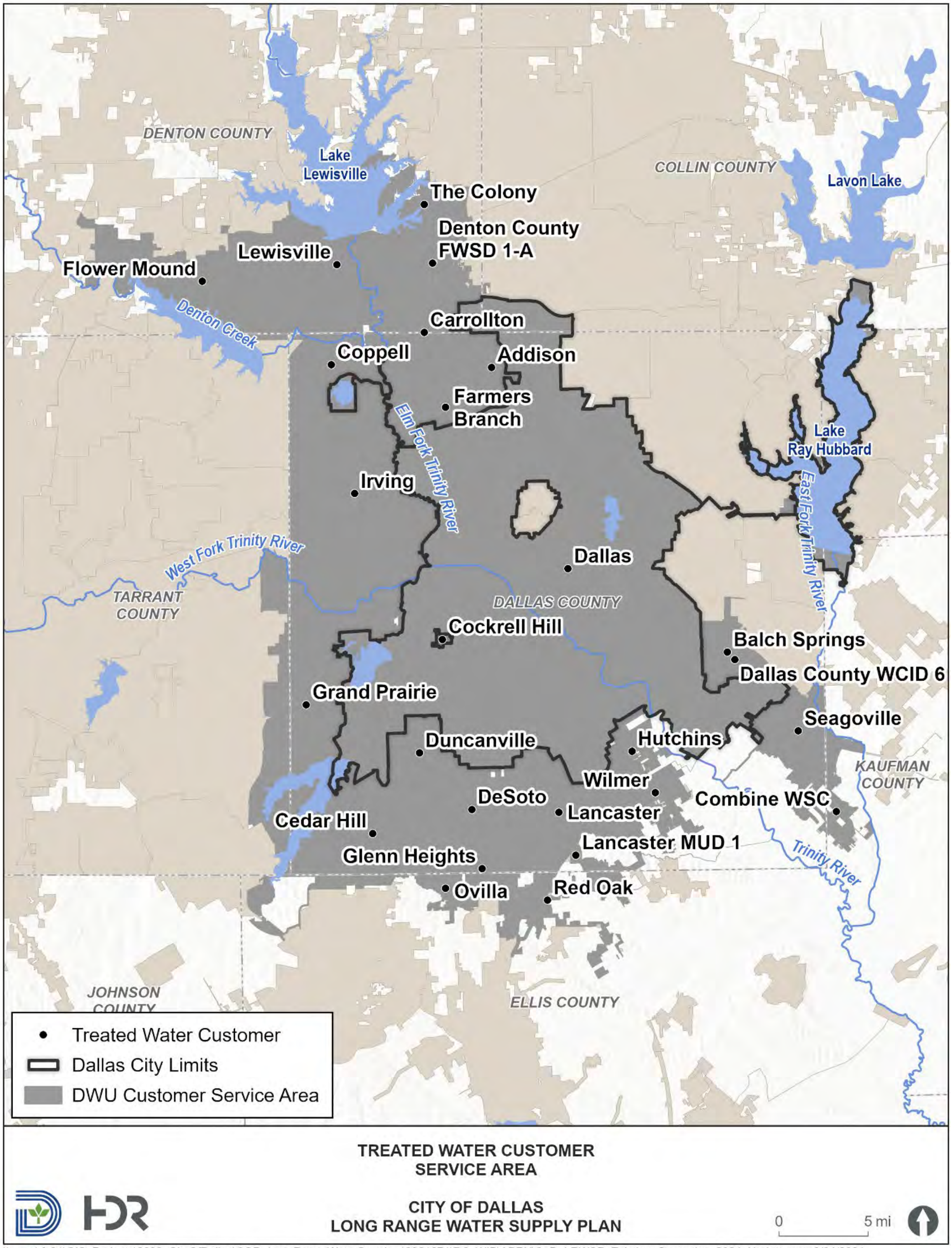
Service area boundaries for the three WTPs are considered approximate as these can and do shift within the distribution system, depending on demands and operating strategy. The Bachman WTP typically serves the downtown and central business areas of Dallas as well as areas to the southwest. The Elm Fork WTP typically serves the northwest portion of the City and several customer cities to the north and west of Dallas. This includes treatment of the City of Irving's water from Lake Chapman as conveyed through the Elm Fork of the Trinity River. The East Side WTP typically serves most of the south, east, and northeast parts of Dallas as well as customer cities to the south and east. The previously planned Southwest Pipeline, Wintergreen Pump Station, and modifications to the Sorcey Pump Station would allow conveyance of East Side WTP treated water to the southwest portion of the City and customer cities to the southwest.

Table 8-1 shows the current and projected (2080) treated water demand percentages for the major customers and Figure 8-5 shows the service area and treated water service customers.

Table 8-1. Dallas Treated Water Customer Contributions to Treated Water Demands

Entity	% of Approximate Current Treated Water Demand	% of Approximate Treated Water Demand in 2080
Dallas Retail	61.6	57.9
Grand Prairie	5.9	5.9
Carrollton	5.4	4.9
Irving	4.1	3.0
DeSoto	2.4	2.0
Cedar Hill	1.7	2.0
Lewisville (55% Treated) Inc Denton County FWSD 1 A	4.4	1.9
Coppell	2.6	1.8
Lancaster (w/ Lancaster MUD 1)	2.0	1.8
Farmers Branch	1.9	1.6
Flower Mound	1.3	1.5
Addison	1.2	1.4
The Colony	1.1	0.9
Glenn Heights (Oak Leaf)	0.6	0.9
All other treated water customers	3.7	3.8

Figure 8-5. Area Served by Dallas and Its Treated Water Customers



\\sanpi-fs01\GIS_Projects\3290_CityOfDallas\COD_LongRangeWaterSupply_10361671\7.2_WIP\APRX\CoD_LRWSP_Existing_Strategies_2024_Update.aprx 9/24/2024

8.2.5 Existing WTP Capacities

Table 8-2 presents the commonly published WTP rated capacities versus the current, reliable plant production capacities as established in the WPFSP. While the total rated production capacity is 900 MGD, the current reliable capacity is approximately 785 MGD, primarily due to the following CLFs at each plant:

- Bachman WTP – hydraulic limitations with raw water pumping
- Elm Fork WTP – process performance limitations at higher loading rates
- East Side WTP – distribution system hydraulic limitations

Table 8-2. Water Treatment Plant Rated and Reliable Production Capacities

Water Treatment Plant	Rated Production Capacity (MGD)	Reliable Production Capacity (MGD)
Bachman	150	145
Elm Fork	310	240
Eastside	440	400
Total	**900**	**785**

The Elm Fork WTP is capable of operating at a capacity closer to 280 MGD. However, process performance limitations become a concern when operating consecutive days at the associated loading rates. The ongoing WQI program will re-set process loading rates to achieve a target, reliable production capacity of 330 MGD.

The East Side WTP treatment process can treat up to approximately 470 MGD and the existing raw water infrastructure can provide this capacity to the plant. However, distribution system hydraulics limit pumping capacity to approximately 400 MGD. The Southwest Pipeline project, Wintergreen Pump Station, and planned Sorcey Pump Station improvements would alleviate this constraint. To achieve 540 MGD, the Stage V filters are required at the plant along with raw water infrastructure improvements.

The WPFSP provides additional details regarding plant capacity limitations and constraints.

8.2.6 Max Day Demand

Table 8-3 presents the historical max day, average day demands, and the corresponding max to average ratio, or peaking factor, from the year 2000 through 2023. Updated drought day demands (per Chapter 4) are multiplied by a representative peaking factor to project max day water demands and evaluate treatment capacity requirements in the future. The 90th percentile value from the data (1.66, which is also the maximum peak day factor calculated since the 2014 LRWSP) and the average value (1.57) were selected for use in the 2024 LRWSP to estimate future max day treatment demands under more conservative conditions (i.e., a hot and dry year) versus less conservative conditions (i.e., an average year).

Table 8-3. Dallas Historical Water Treatment Plant Production

Year	Max Day (MGD)	Average Day (MGD)	Max to Avg Ratio
2000	789.6	462.3	1.71
2001	734.4	450.2	1.63
2002	641.4	422.4	1.52
2003	692.2	423.5	1.63
2004	584.1	399.3	1.46
2005	621.3	437.2	1.42
2006	681.3	457.4	1.49
2007	574.8	386.2	1.49
2008	670.2	416.9	1.61
2009	625.7	389.8	1.61
2010	637.9	400.3	1.59
2011	682.6	398.3	1.71
2012	649.2	400.9	1.62
2013	584.2	379.5	1.54
2014	542.1	381.5	1.42
2015	615.5	371.3	1.66
2016	584.8	368.6	1.59
2017	520.7	365.6	1.42
2018	594.3	363.6	1.63
2019	590.2	375.9	1.57
2020	575.1	373.1	1.54
2021	533.8	372.7	1.43
2022	657.8	416.1	1.58
2023	701.1	422.9	1.66

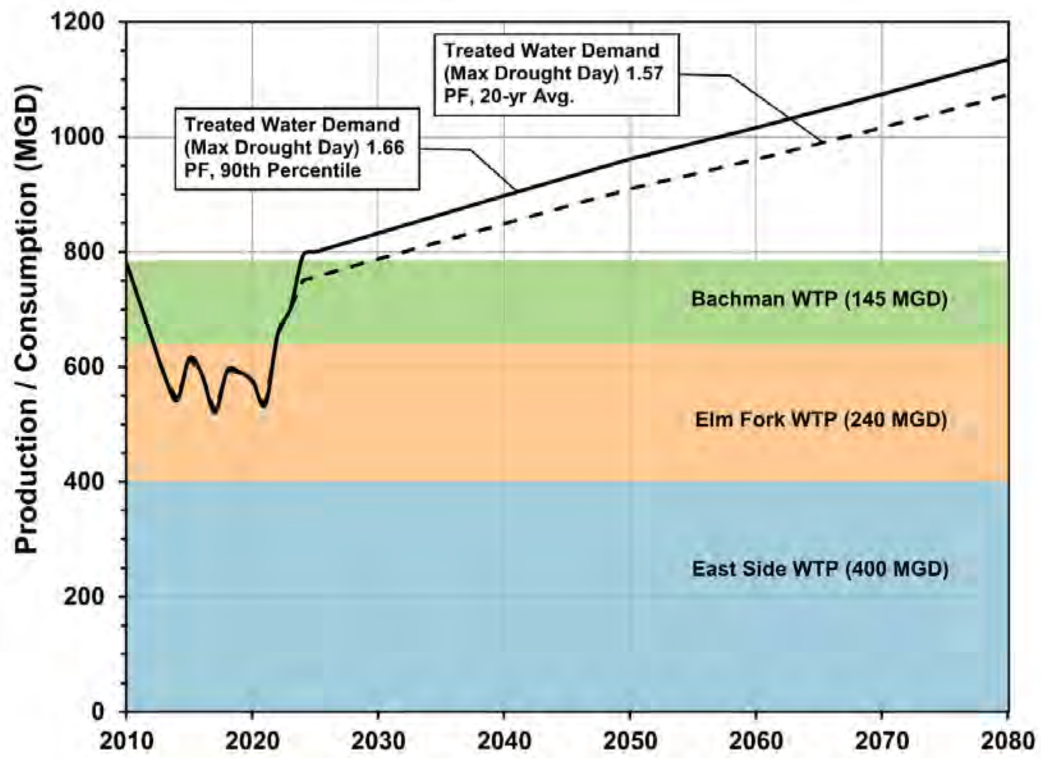
Table 8-4 presents resulting max day demand projections using a peaking factor of 1.66.

Table 8-4. Projected Dallas Max Day Demands

Year	Dallas Projected Treated Water Drought Day Demands (MGD)	City of Irving Treated Water Drought Demand on Dallas (MGD)	Combined Total Drought Demand (MGD)	Projected Max Day Demand (MGD) (Drought Day X 1.66)
2030	467.2	33.8	501.0	832.5
2040	504.5	35.8	540.3	897.7
2050	542.9	35.8	578.7	961.6
2060	575.7	35.8	61135	1015.9
2070	610.6	35.9	646.5	1074.2
2080	647.0	35.9	682.9	1134.6

Figure 8-6 depicts the existing, reliable treatment capacity (all plants combined) relative to projected max day water demands using both peaking factors.

Figure 8-6. Existing Treatment Capacity vs. Projected Max Day Water Demands for DWU System



As shown, the reliable treatment production capacity must be increased to meet current and near-term max day demands. The recorded max day demand in 2023 of 701.1 MGD accounted for 89.3% of the existing total water treatment plant capacity (based on a reliable, total capacity of 785 MGD).

8.3 Future Water Treatment Plant Capacity Needs

This section presents water treatment plant capacity needs to meet projected max day treated water demands to the Year 2080. From an overall system perspective, it is evident from Figure 8-6 that additional, reliable treatment production capacity is needed as soon as possible. Even with pushing the Elm Fork WTP to operate at a capacity up to 280 MGD, additional reliable capacity is needed by about 2030 to 2032 (similar to projections noted in the WPFSP).

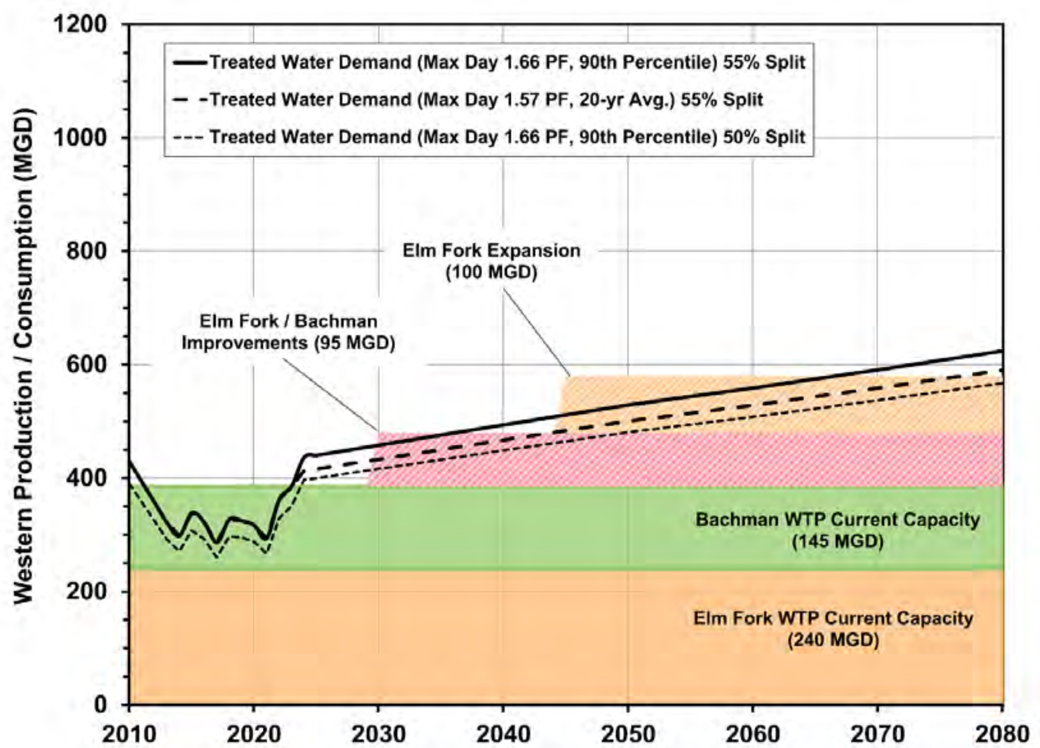
For the pursposes of determining when and how much additional capacity is needed in the future, the Western and Eastern Subsystem capacities are assessed separately. The figures in the following sections show max day water demand curves using both peaking factors as well as two different demands splits. Curves are shown to reflect max day demands if each subsystem were to provide 55% of the max day demand versus providing an even split, or 50% of the max day demand. Targeting 55% of the max day demand in each subsystem will provide DWU with additional system redundancy as well as increased operational flexibility, a goal set in the 2014 LRWSP and affirmed in the WPFSP.

8.3.1 Western Subsystem WTP Capacity Needs

Figure 8-7 shows future treatment capacity needs for the Western Subsystem considering max day water demands to 2080. Key findings include:

- Max day water demands are slightly increased as compared to previous projections, slightly accelerating the timeline for additional capacity needs when compared to timelines noted in the WPFSP and March 2024 CIP,
- Restoring reliable production capacity (to 330 MGD) at the Elm Fork WTP via the WQI program is critical to meeting current and near-term demands,
- Future plant capacity expansion may be needed at the Elm Fork WTP (or other alternative) in the 2040 to 2050 timeframe (depicted in 2045) depending on actual water demand trends moving forward, and
- Additional plant capacity expansion may be needed in the 2070 to 2080 timeframe.

Figure 8-7. Future Western Subsystem Treatment Capacity vs. Projected Max Day Demands

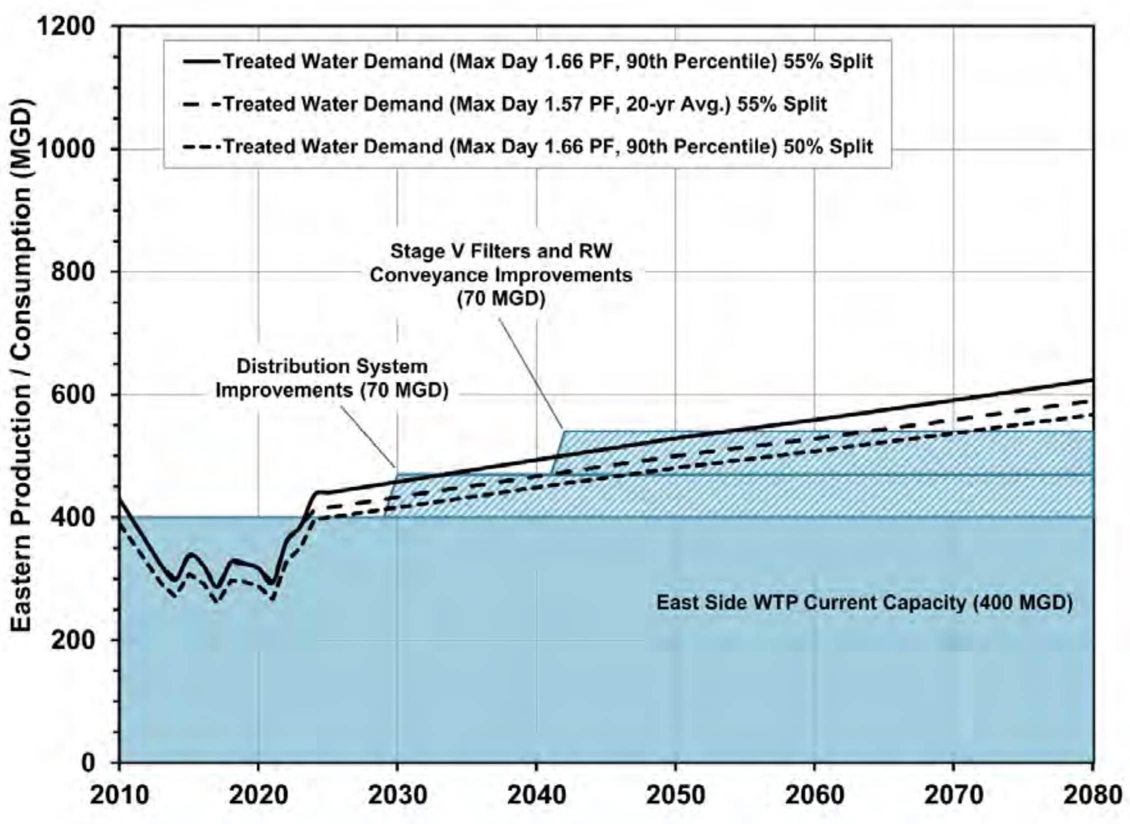


8.3.2 Eastern Subsystem WTP Capacity Needs

Figure 8-8 shows future treatment capacity needs for the Eastern Subsystem considering max day water demands to 2080. Key findings include:

- Max day water demands are slightly increased as compared to previous projections, slightly accelerating the timeline for additional capacity needs when compared to timelines noted in the WPFSP and March 2024 CIP,
- Addressing distribution system CLFs (or other alternative) is critical to meeting current and near-term demands,
- The Stage V filters and raw water infrastructure improvements (i.e., Tawakoni Balancing Reservoir expansion and 144-inch diamter pipeline) may be needed in the 2035 to 2045 timeframe (depicted in 2042) depending on actual water demand trends moving forward, and
- Additional plant capacity expansion may be needed in the 2055 to 2070 timeframe

Figure 8-8. Future Eastern Subsystem Treatment Capacity vs. Projected Max Day Demands

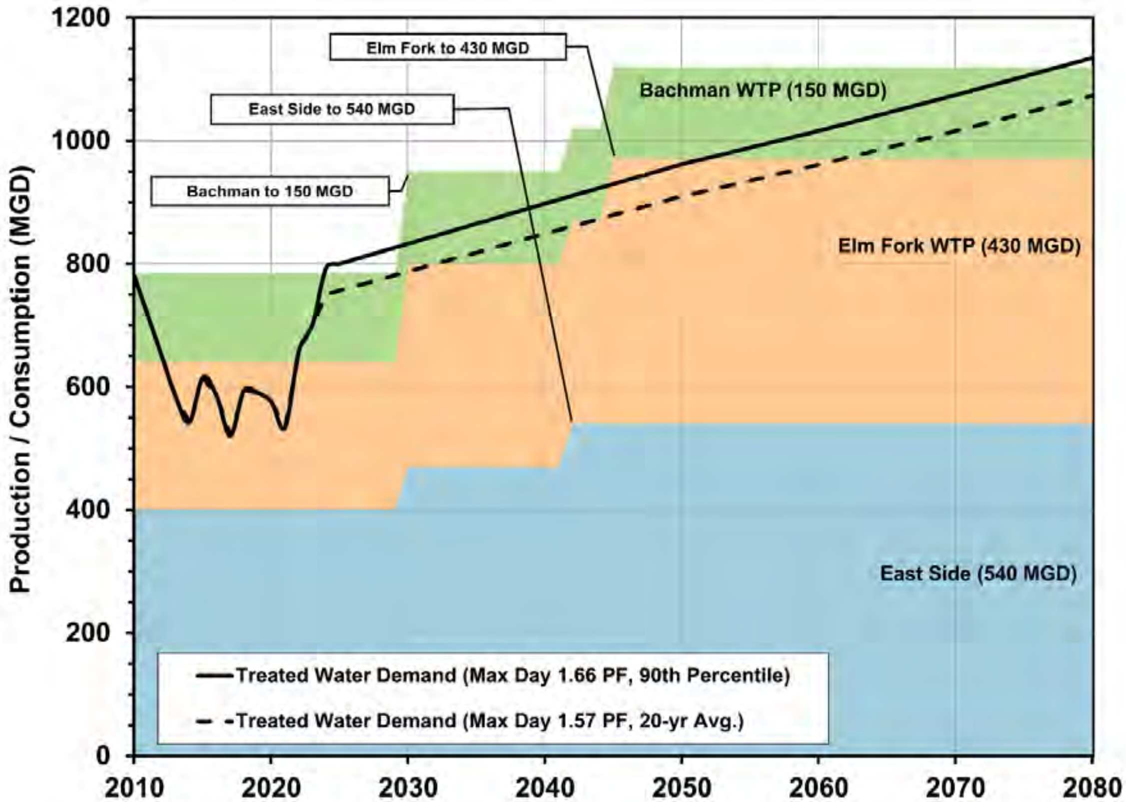


8.3.3 Combined WTP Capacity Perspective

Figure 8-9 combines Figure 8-7 and Figure 8-8 to provide an overall, system-wide perspective. Key findings include:

- Ongoing projects at the Elm Fork WTP (WQI program) and Southwest Pipeline are critical to meet current and near-term max day demands,
- While there appears to be enough capacity with future planned improvements, demand projections are slighlty higher than those developed previously in the 2014 LRWSP and higher than the Water Delivery System Comprehensive Assessment and Update. It is not certain that pumping and distribution has enough capacity (and operational flexibility) to move water to needed areas in the system, particularly to the southwest which is currently experiencing elevated demands sooner than expected.

Figure 8-9. Combined Treatment Capacity vs. Projected Max Day Demands



8.4 Raw Water Conveyance

The sections that follow provide a summary of the existing raw water conveyance systems and the existing capacities.

8.4.1 Overview of Raw Water Conveyance Systems

Figure 8-10 illustrates the existing DWU raw water conveyance system and its key components. The conveyance system is comprised of the Western Raw Water Supply Subsystem and the Eastern Raw Water Supply Subsystem.

8.4.1.1 WESTERN RAW WATER SUPPLY SUBSYSTEM

The Western Raw Water Supply Subsystem is a gravity system and provides water supply for the Bachman and Elm Fork WTPs. This subsystem currently includes:

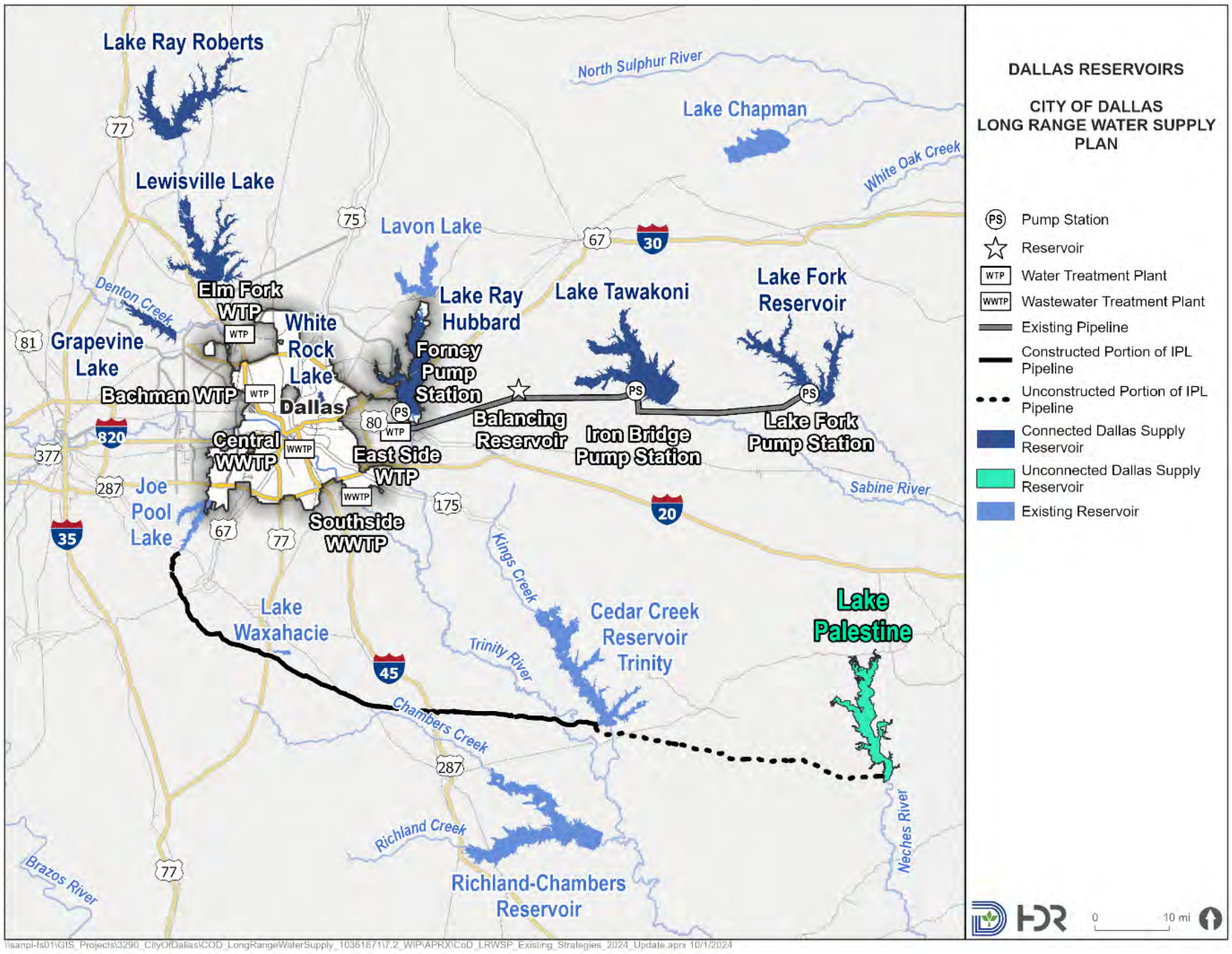
- Ray Roberts Lake – the furthest source to the north; water is released to the Elm Fork of the Trinity River where it flows into Lewisville Lake.
- Lewisville Lake – water is released into the Elm Fork of the Trinity River below the Lewisville Lake Dam where it joins with Denton Creek and flows downstream to Carrollton and Frazier Dams.
- Grapevine Lake – water is released into Denton Creek upstream of where Denton Creek converges with the Elm Fork of the Trinity River.
- Elm Fork WTP Intake – located upstream of the Carrollton Dam on the Elm Fork of the Trinity River where flows from the upstream lakes are diverted through two 72-inch diameter gravity pipelines to Pump Station 1 and through one 96-inch diameter pipeline to Pump Station 2 at the WTP; the pump stations then pump the raw water to the ozone contact structure at the head of the treatment process.
- Bachman WTP Intake – located about 8 miles downstream of the Carrollton Dam and upstream of Frazier Dam on the Elm Fork of the Trinity River where an initial intake diverts water to Fishing Hole Lake; water is diverted from Fishing Hole Lake through a second intake and 96-inch pipeline to the WTP’s Raw Water Pump Station.

8.4.1.2 EASTERN RAW WATER SUPPLY SUBSYSTEM

Dallas’ Eastern Raw Water Supply Subsystem provides water supply for the Eastside WTP and includes:

- Lake Fork –the Lake Fork Pump Station pumps raw water to the Tawakoni connector near the Iron Bridge Pump Station through a 108-inch diameter pipeline and can also divert water to Lake Tawakoni.
- Lake Tawakoni – the Iron Bridge Pump Station pumps raw water to the Tawakoni Balancing Reservoir through 72-inch and 84-inch diameter pipelines.
- Tawakoni Balancing Reservoir – water flows by gravity through 72-inch diameter and 84-inch diameter pipelines to the Eastside WTP.
- Lake Ray Hubbard – the Forney Pump Station pumps raw water from Lake Ray Hubbard to the Eastside WTP through 90-inch and 96-inch diameter pipelines.

Figure 8-10. Dallas Raw Water Conveyance Subsystem



8.4.2 Existing Raw Water Conveyance System Capacities

Table 8-5 provides a summary of the existing raw water pumping (or pipeline) capacities for the Western and Eastern Raw Water Supply Subsystems relative to the 2080 average day supply. Based off a review of Dallas' average and peak day demands, the ratio of pumping (or pipeline) capacity (whichever is limiting) to supply should equal or exceed 1.66 for that component of the system to meet its share of peak day demands.

For the Western Raw Water Conveyance Subsystem, the ratio of current capacity to 2080 supply is 3.0 and meets the recommended ratio of 1.66 to meet peak day requirements. The Elm Fork WTP and Bachman WTP conveyance subsystems provide a ratio well above 1.66.

Table 8-5. Raw Water Conveyance System Capacities Compared to 2080 Supplies

System Component	Pumping Capacity (MGD) [a]	Pipeline Capacity (MGD)	2080 Average Day Supply [b] (MGD)	Ratio of Capacity to 2080 Supply [c]
Western Subsystem Raw Water Conveyance				
Elm Fork WTP Supply and Raw Water Pumping	338	> 338	107.1	3.2
Bachman WTP Supply and Raw Water Pumping	160	> 160	57.6	2.8
Western Subsystem Total	**498**	**> 498**	**164.7**	**3.0**
Eastern Subsystem Raw Water Conveyance				
Lake Fork, Lake Fork Pump Station, and 108-inch Pipeline to the Tawakoni Interconnect	212	215	91	2.4
Lake Tawakoni, Iron Bridge Pump Station, and 72-inch / 84-inch Pipelines to Tawakoni Balancing Reservoir and on to East Side WTP	230	215 [d]	221.4[e]	0.97 [f]
Lake Ray Hubbard, Forney Pump Station, and 90-inch / 96-inch Pipelines [g]	310	300	45.4	6.6
Eastern Subsystem Total	**752**	**515**	**270.8**	**1.9**

[a] Firm capacity (largest pump out of service) based on system modeling.

[b] Calculated using the 1950s critical drought period, 2080 sediment conditions and 8-degree F increase in historical temperature.

[c] Should be greater than 1.66 to meet peak day requirements. Capacity used to calculate this ratio is based on the limiting factor when comparing pumping and pipeline capacities.

[d] Combined capacity of the 72-inch and 84-inch diameter pipelines from Lake Fork and Lake Tawakoni is limited by the 100-psi pressure rating of the 72-inch diameter pipeline at Duck Creek crossing. Previous documentation and assessments indicate a maximum total capacity of the combined pipelines ranging from 210 MGD (April 2011 DWU CIP Program Briefing) to 215 MGD (August 2012 Draft Preliminary Engineering Report for the Iron Bridge Pump Station Rehabilitation, HDR, Inc.).

[e] Includes combined yields of Lake Fork and Lake Tawakoni.

[f] This system is generally not used for peak deliveries, but the 0.95 is a limiting factor for delivering the combined supplies from Lakes Tawakoni and Fork.

[g] Since the 2014 LRWSP Dallas successfully amended the LRH water right to increase the diversion (but not reliable supply) from Lake Ray Hubbard to 186 MGD for operational efficiencies. This changes the ratio of 6.6 above to 1.6.

As shown for the Eastern Raw Water Conveyance Subsystem, the primary limiting capacity factor is the pipeline system connecting the Lake Fork and Tawakoni supplies from the Lake Fork / Lake Tawakoni interconnect to the Eastside WTP. DWU has continued land acquisition and design activities for the addition of a 144-inch diameter pipeline to parallel the existing 72-inch and 84-inch diameter pipelines (depicted previously in Figure 8-10) from the Iron Bridge Pump Station to the Tawakoni Balancing Reservoir and on to the East Side WTP. Adding the 144-inch diameter pipeline will address reliability concerns with the existing pipelines while providing greater flexibility in removing conveyance limitations. Per information provided by DWU, the 144-inch diameter pipeline will add 366 MGD of capacity to the Eastern Raw Water Conveyance Subsystem. Thus, the current combined Lake Fork and Iron Bridge Pump Station capacity of 442 MGD could be utilized and the ratio of capacity to 2080 supply would increase from 0.97 to 1.39. While the current overall Eastern Subsystem ratio is about

1.9 the ratio will increase to 2.5 by 2080 assuming completion of the 144-inch diameter pipeline.

8.4.2.1 LIMITING FACTORS

Table 8-6 presents a summary of raw water conveyance system total capacities compared to the existing WTP capacities and using current (2030) supplies.

Table 8-6. Comparison of Existing Conveyance and Current Limiting Treatment Capacities

System Component	Current (2020) Supply (MGD)[a]	Raw Water Pumping Capacity (MGD)	Pipeline Capacity (MGD)	WTP Limiting Capacity (MGD) (from Table 8-3)
Western Raw Water Conveyance and Treatment Subsystem				
Elm Fork WTP	177.0	338	> 338	240 to 280
Bachman WTP		160	> 160	145
Western Subsystem Total		498	> 498	385 to 425
Eastern Raw Water Conveyance and Treatment Subsystem				
East Side WTP	307.1	752	515	400
Eastern Subsystem Total		752	515	400

[a] From Table 5-8.

8.5 Future Raw Water Conveyance System Capacity Needs

This section highlights raw water conveyance system capacity needs to meet projected water demands to 2080. In general, the raw water conveyance systems must be able to carry the required capacity to meet treated water demands as presented in this plan plus any additional capacity to compensate for water loss and internal WTP water use.

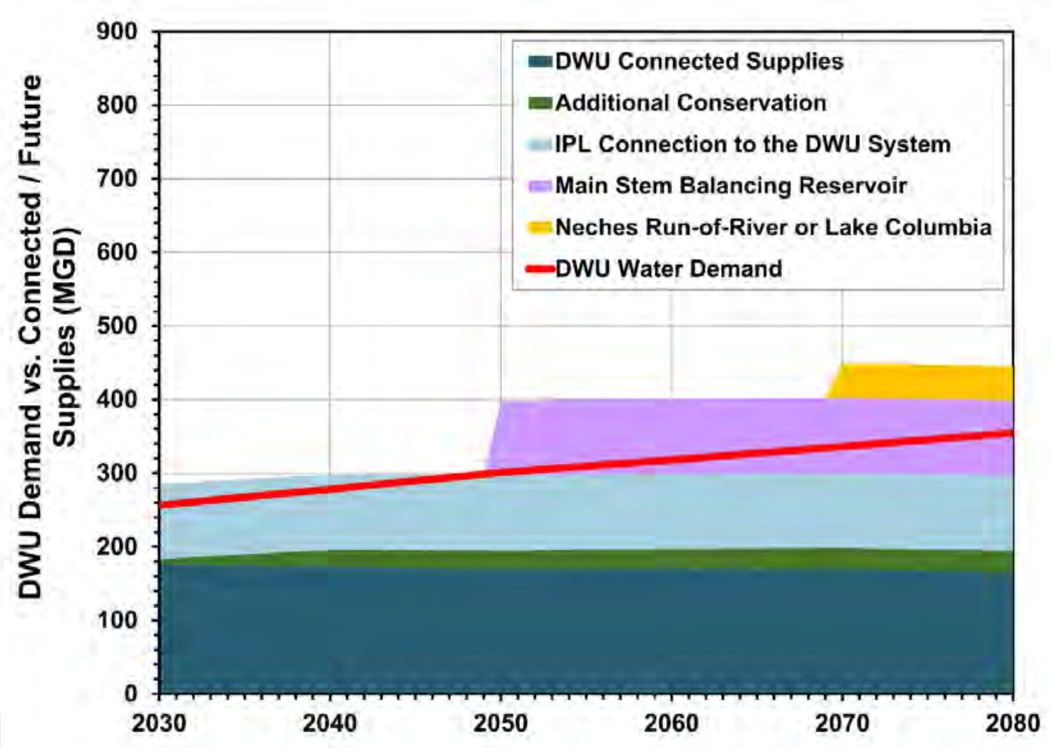
8.5.1 Western Subsystem Raw Water Conveyance Capacity Needs

Figure 8-11 shows the projected Western Supply Subsystem firm water supply (based on 1950s drought) to 2080 along with recommended water supply strategies in relation to the drought day water demands.

There is presently an existing water supply deficit in the Western Supply Subsystem during drought conditions. A portion of this deficit can currently be offset by the surplus supply in the Eastern Supply Subsystem and transfers through Dallas' distribution system, as Dallas' demands grow, there is increasing risk for water supply shortages. There is currently not a sufficient buffer in the Eastern Supply Subsystem to offset the entire Western Supply Subsystem deficit. From the vantage point of the Western Supply Subsystem, the on-going Integrated Pipeline (IPL) Project to connect Lake Palestine needs to be connected to Dallas' system in the 2030 decade to minimize the risk of future water supply shortages during drought conditions. Rapidly increasing treated water demands in the southwest are also a driver to connect this supply. Considering demands for Dallas' Western Supply Subsystem, the Main Stem Balancing Reservoir (MSBR) is needed by about 2050, although the MSBR could be constructed sooner to provide an increased buffer for the Western Supply Subsystem.

The supply surplus provided by implementation of the recommended strategy in 2070 will add an additional supply buffer to both the Western and Eastern Supply Subsystem. The Western Supply Subsystem buffer will be beneficial as 2080 approaches and implementation of the recommended strategy for the Eastern Supply Subsystem begins.

Figure 8-11. Projected Supply vs. Drought Day Demands for DWU's Western Supply Subsystem



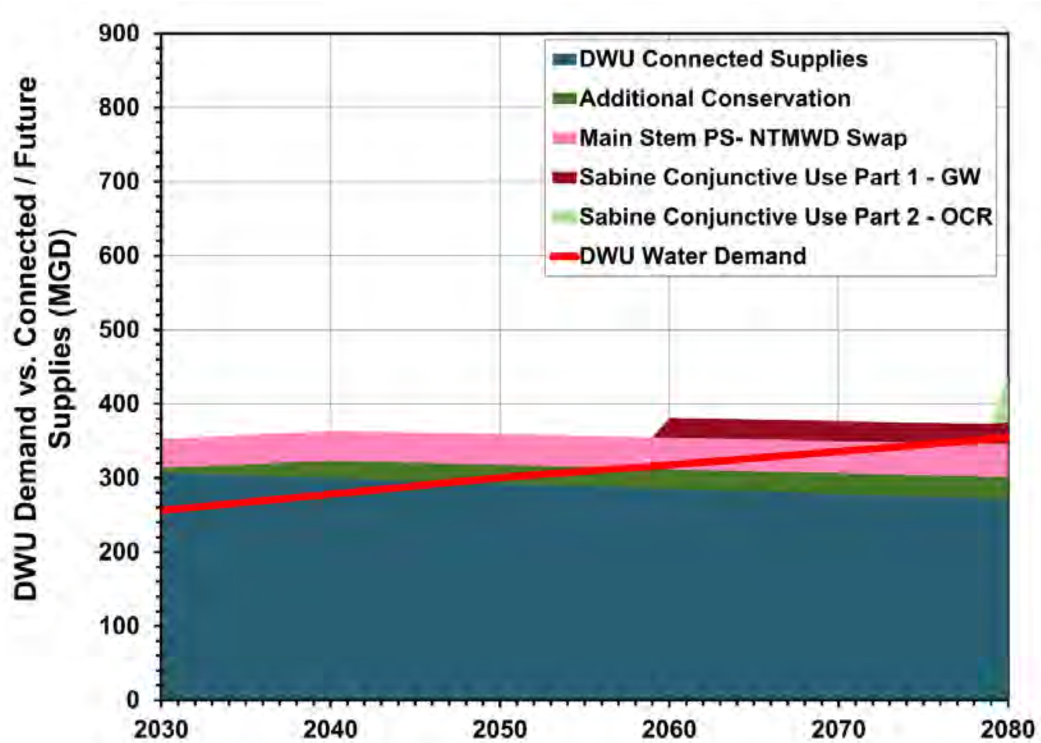
8.5.2 Eastern Subsystem Raw Water Conveyance Capacity Needs

Figure 8-12 shows the projected Eastern Supply Subsystem firm, connected water supply (based on 1950s drought) to 2080 along with recommended water supply strategies in relation to the drought day water demands.

While there is currently an existing surplus in the Eastern Supply Subsystem until about 2047, the recommended water supply strategies include completion of the swap agreement and implementation of the Main Stem Pump Station by the 2030 decade. The pump station has already been constructed due to needs of the North Texas Municipal Water District (NTMWD)). The surplus will provide an additional buffer for the Western Supply Subsystem until the MSBR strategy is implemented around 2050. A supply deficit is not projected to occur in the Eastern Supply Subsystem within the 2024 LRWSP planning period with implementation of the recommended water supply strategies.

Inclusion of Sabine Conjunctive Use as a phased strategy with implementation of Carrizo-Wilcox groundwater (phase 1) in 2060 and then the off-channel reservoir (phase 2) in 2080 provides a supply buffer in the Eastern Supply Subsystem.

Figure 8-12. Projected Supply vs. Drought Day Demands for DWU's Eastern Supply Subsystem



8.5.3 Future System

Figure 8-13 illustrates the future raw water conveyance system based on implementation of the recommended water supply strategies including:

Western Supply Subsystem

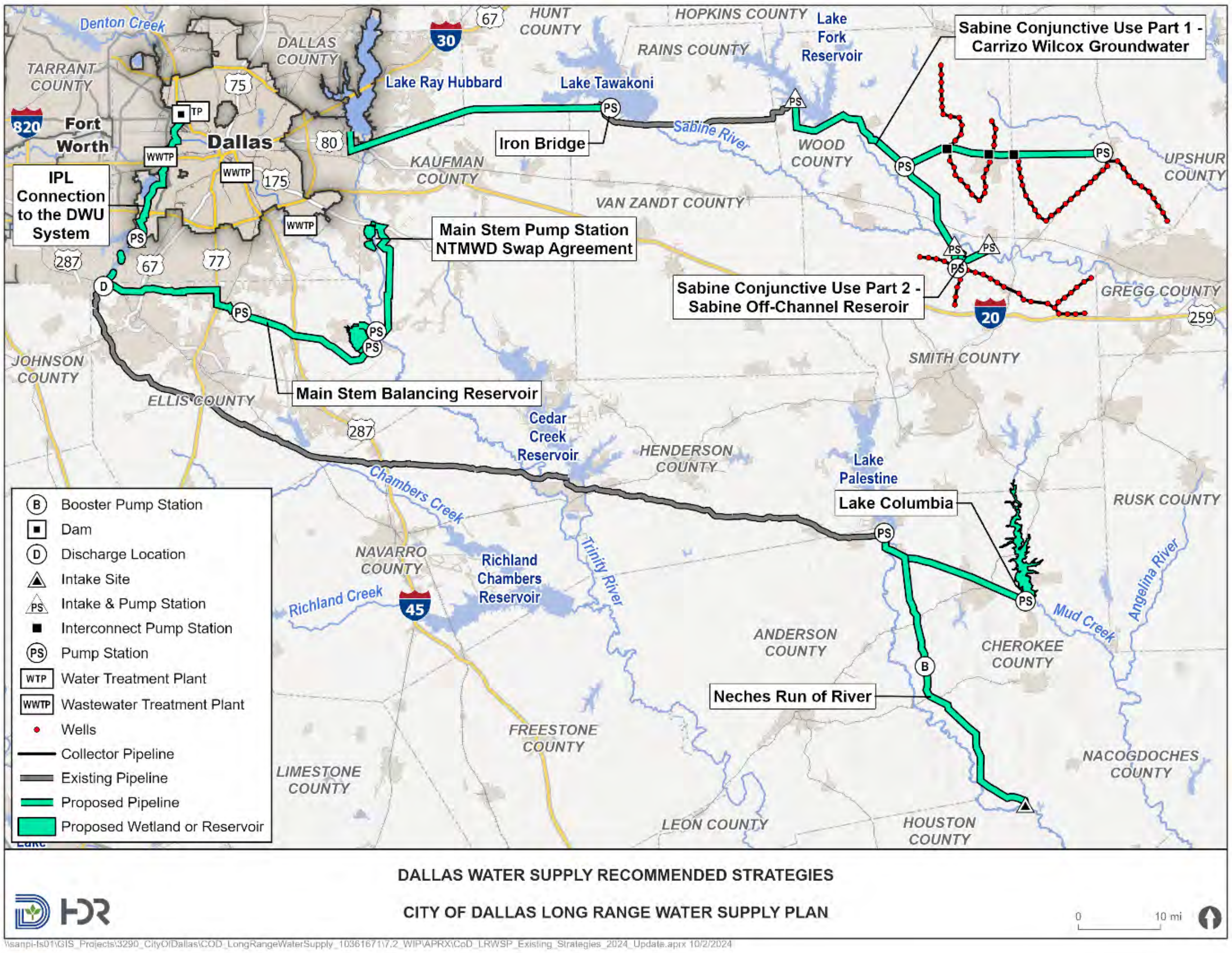
- Joint IPL project with the Tarrant Regional Water District (TRWD) – includes various intake / pump stations and large diameter transmission pipelines (project on-going)
- Dallas portion of the IPL project to connect Lake Palestine – includes 150 MGD intake and pump station with 84-inch diameter transmission pipeline
- Conveyance of IPL water – includes alternatives such as the proposed gravity flow through Joe Pool Lake with pipeline conveyance to connect to the Bachman WTP (other alternatives currently being evaluated by DWU); connection of the future MSBR supply may require parallel transmission pipelines depending on the selected approach

- Western Subsystem WTP Expansion – infrastructure needs depend on location of the delivery of IPL water to DWU system (currently being evaluated further by DWU)
- Main Stem Balancing Reservoir – includes off-channel storage reservoir with sedimentation basin, 127.5 MGD intake and pump station with 72-inch diameter intake pipeline, and in-line transmission pump station(s) along a 36.5-mile 90-inch diameter transmission pipeline to the Joe Pool Lake area
- Neches River Basin Supply (Neches Run-of-River or Lake Columbia)
    - Neches Run-of-the-River – includes channel dam, 91 MGD intake and pump station, and in-line transmission pump station along a 42-mile 72-inch diameter transmission pipeline to Lake Palestine
    - Lake Columbia – includes reservoir and dam, 50 MGD intake and pump station, and 20-mile 42-inch diameter transmission pipeline to Lake Palestine

Eastern Supply Subsystem

- 144-inch diameter pipeline from the Lake Tawakoni / Lake Fork Interconnect to the Tawakoni Balancing Reservoir (TBR) and on to the East Side WTP (includes TBR expansion)
- Sabine Conjunctive Use
    - Part 1 – Carrizo-Wilcox Groundwater – includes 90 Queen City wells, 10 Carrizo Wells, and 10 Wilcox Wells, 24-42-inch and 78-inch transmission pipelines from the well fields and anticipated OCR to the Lake Fork Pump Station
    - Part 2 – Off-Channel Reservoir – includes 258 MGD intake and pump station, and two 90-inch diameter short distance transmission pipelines to the OCR with 67,200 ac-ft of storage.

Figure 8-13. Dallas Future Raw Water Conveyance System



8.6 Recommended Water Treatment Plant and Raw Water Conveyance System Infrastructure Improvements

This section summarizes recommended water treatment plant and raw water conveyance system infrastructure improvements to meet future capacity needs.

8.6.1 On-going and Previously Planned Improvements

Table 8-7 provides a summary of previously planned water supply and treatment infrastructure projects (from the March 2024 CIP) with noted benefits / significance to the Dallas system. Only select, higher cost / higher priority projects and programs are shown. Refer to the March 2024 CIP for additional projects in the 10-year CIP and 30-year outlay.

Table 8-7. Currently Planned Water Supply and Treatment Infrastructure Projects

Project	Status	Benefits / Significance
Western Raw Water Supply and Treatment Subsystem		
IPL Connection *Connect Lake Palestine*	Planning / Evaluation	Balances water supply between east/west subsystems according to water demand; provides increased supply capacity and redundancy while reducing risk of potential water supply shortages during droughts.
Elm Fork WTP *Water Quality Improvements Program (CMAR delivery)*	Design	Achieves water quality objectives of increasing biological and chemical stability of the treated water to reduce nitrification, corrosion, and residual loss in the distribution system; includes plant improvements to increase process and equipment reliability achieving a rated production capacity of 330 MGD.
Elm Fork WTP *New Clearwells*	Future	Addresses aging clearwells and associated infrastructure while providing layout to incorporate additional clearwell volume.
Bachman WTP *High-Rate Treatment Trains and Filters*	Future	Replaces aging treatment process facilities and plant infrastructure while creating site space to incorporate additional treatment technology and potentially additional capacity in the future.
Bachman WTP *PFAS Treatment*	Planning	Provides PFAS treatment strategy recommendations and implementation plan if needed for regulatory compliance; likely triggers the high-rate treatment trains and filters much sooner due to site constraints and the need to incorporate additional treatment technology.
Eastern Raw Water Supply and Treatment Subsystem		
Iron Bridge Pump Station *Rehabilitation*	Design	Provides rehabilitation of priority items to extend service life at the existing pump station.
Iron Bridge Pump Station *Replacement*	Future	Replaces the existing intake and pump station with a new, more efficient facility that will meet current industry standards and system operational requirements.
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to East Side WTP*	Design (on hold) / Future	Increases reliability of eastern conveyance infrastructure; increases capacity to allow concurrent delivery of Lake Fork and Lake Tawakoni water (with modifications to the Interconnect) to East Side WTP while adding additional system redundancy if any of the 3 reservoirs is not usable; further reduces risk of water shortage in the system and increases ratio of capacity to firm supply.
Tawakoni Balancing Reservoir *Rehabilitation*	Future	Provides rehabilitation of high priority PLFs.
Tawakoni Balancing Reservoir *Expansion*	Future	Provides 1 day of storage for expanded 540 MGD East Side subsystem; increases capacity coinciding with pump station and pipeline improvements.
East Side WTP *Residuals Processing and Handling Improvements*	Planning / Design	Addresses full basins and restores basin capacity; separates sedimentation basin blow-down solids from spent filter backwash to improve plant recycle water quality and adds residuals processing through a series of projects.
East Side WTP *Stage V Filters*	Design (on hold)	Completes the Eastside WTP expansion to 540 MGD.
Southwest Pipeline, Wintergreen Pump Station, and Sorcey Pump Station Improvements	Planning / Design	Addresses CLF limiting the East Side WTP to 400 MGD and increases pumping capacity from East Side WTP to 540 MGD or more; provides transfer of treated water into the southwest portion of the system for additional flexibility in meeting demand.

As exhibited in Table 8-7, DWU has already put in motion several projects that will position the utility for meeting future water supply and treatment needs. For a more comprehensive listing of planned water production facility projects and timing, refer to additional details in the WPFSP and March 2024 CIP.

8.6.2 Required Improvements and Associated Project Drivers

Additional water supplies and treatment capacity will be needed between now and 2080 and the goal of balancing the Western and Eastern Supply Subsystems creates some potential shifts in infrastructure needs and prioritization. Table 8-8 presents the projects noted in Table 8-7 with the addition of infrastructure improvement programs associated with newly identified water supply and treatment capacity needs, many of which are enumerated in the WPFSP and CIP Summary Maps. Projects in Table 8-7 that are already in construction are not shown in Table 8-8. Also, Table 8-8 notes target completion dates per the current March 2024 CIP versus updated completion dates based on the updated 2024 LRWSP water demands for comparison and understanding of CIP implications. The projects are categorized in terms of the respective drivers based on:

Project Driver Definition

- G = growth / capacity driven
- R = regulatory / water quality driven
- M = maintenance / reliability driven

Project timelines are generally based on when the improvements are required to meet projected water demands. However, some projects may be deemed more critical when considering the associated benefits and risk per the March 2024 CIP and prioritization tool.

While a few projects shown are related to high service pumping and distribution system transmission mains, the scope of the 2024 LRWSP did not include identification of needed distribution system improvements on a system-wide basis. The projects shown are those that correspond to readily identifiable conveyance and treatment plant capacity limitations through an understanding of previously planned projects, completed studies, and discussions with DWU staff.

Table 8-8. Summary of Future Water Supply Strategies and Treatment Infrastructure Projects

Project	Drivers	March 2024 CIP Complete By	Updated Complete By[a]	Capital Cost [b]
Target Projects for Completion by 2035				
Iron Bridge Pump Station *Rehabilitation*	M	2027	2027	$8.5 M
East Side WTP *Residuals Processing and Handling Improvements (Lagoon 4 and 5)*	M	2028	2028	$29 M
Lake June PS Phase 1 (Reservoirs)	M	2028	2028	$70 M
Southwest Pipeline Phase 1	G	2028	2028	$113 M
IPL Connection *Connect Lake Palestine*	G	2040[c]	2040[c]	$393 M
Bachman WTP *High-Rate Treatment Trains and Filters*	R / M	2030	2030	$240 M
Bachman WTP *PFAS Treatment*	R	2030	2030	$103 M
Wintergreen Pump Station - Initial Stage	G	2036	**2030**	$80 M
Wintergreen Pump Station - Final Buildout	G	2039	**2030**	$26 M
Southwest Pipeline Phase 2	G	2036	**2030**	$200 M
Southwest Pipeline Phase 3	G	2040	**2030**	$230 M
Elm Fork WTP *Water Quality Improvements Program (CMAR delivery)*	R / G	2032	2032	$491 M
East Side WTP *Residuals Processing and Handling Improvements (Off-site Lagoons)*	M	2032	2032	$33 M
Lake June PS Phase 2	M	2032	2032	$170 M
Tawakoni Balancing Reservoir *Rehabilitation*	M	2032	2032	$19 M
72-inch Treated Water Pipeline *Bachman WTP to Elm Fork WTP*	G / R / M	2033	2033	$90 M
East Side WTP *Residuals Processing and Handling Improvements (On-stie PS)*	M	2035	2035	$34 M
Target Projects for Completion by 2050				
Elm Fork WTP *New Clearwells*	M / R	2036	2036	$93 M
Iron Bridge Pump Station *Replacement*	M	2037	2037	$94 M
Tawakoni Balancing Reservoir *Expansion*	G	2041	2041	$28 M
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to East Side WTP*	G / M	2043	**2042**	$390 M
East Side WTP *Stage V Filters*	G	2052	**2042**	$55 M

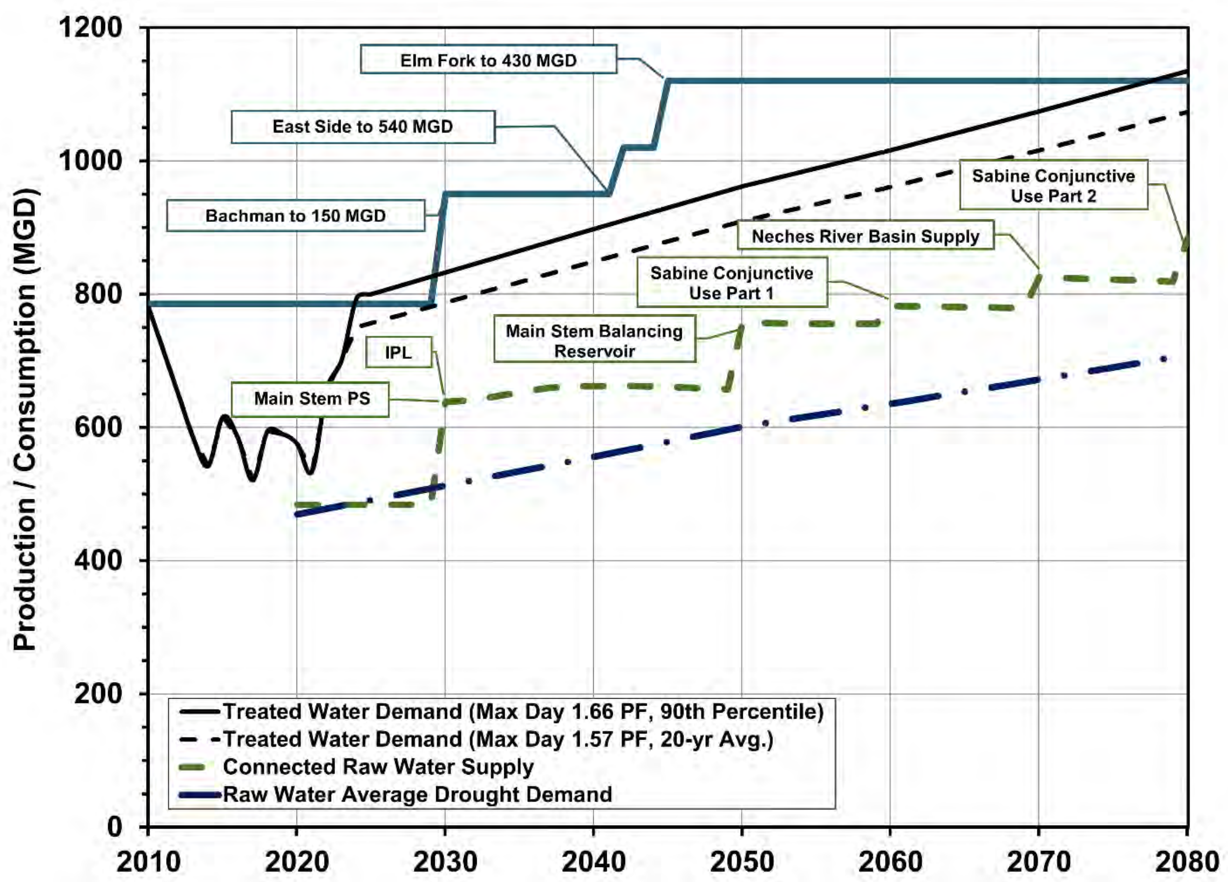
Project	Drivers	March 2024 CIP Complete By	Updated Complete By[a]	Capital Cost [b]
Western WTP Expansion	G	2055	**2045**	TBD
Main Stem Balancing Reservoir (DWU) Pump Station / Pipeline	G	2050	2050	$1,143 M
Target Projects for Completion by 2060				
Sabine Conjunctive Use Phase 1 - Groundwater	G	-	2060	$485 M
Target Projects for Completion by 2070				
Eastern WTP Expansion	G	-	2065	TBD
Neches River Basin Supply (will only implement one project)	-	-	-	-
Neches Run-of-River	G	-	2070	$512 M
Lake Columbia	G	-	2070	$361 M
Target Projects for Completion by 2080				
Sabine Conjunctive Use Phase 2 – Off Channel Reservoir	G	-	2080	$622 M
50-Year Target Projects Total				***$6,112.5 M***

[a] Complete by dates based on updated 2024 LRWSP water demand projections.
[b] Capital costs are for engineering and construction and are based on costs reflected in the March 2024 CIP unless otherwise noted.
[c] Previously 2027 per the 2014 LRWSP and CIP. Currently needed in the 2030's decade.
Red bold text indicates a change from previous CIP planning efforts

8.6.3 Implementation Timeline

Figure 8-14 presents the proposed water supply and treatment infrastructure implementation timeline based on the needs as identified and prioritized in Table 8-8. Individual projects are not depicted but are grouped with milestones to coincide with the listing of improvements.

Figure 8-14. Water Supply and Treatment Infrastructure Implementation Timeline



8.6.4 Summary of Conclusions and Recommendations for Water Treatment Plant and Raw Water Conveyance System Capacity Needs

Conclusions and recommendations pertaining to water treatment plant and raw water conveyance system capacity needs are summarized below.

8.6.4.1 CONCLUSIONS

- Current, combined water treatment reliable production capacity is about 785 MGD considering current treatment and distribution system hydraulic limitations.
- Treated water demands will exceed 785 MGD combined peak day capacity by about 2030 or sooner.
- Completing previously planned projects in the Western Subsystem over next several years can address PLFs and CLFs and increase reliable water treatment capacities to meet near term needs.

- Additional water supply (to be provided by the IPL Project and Lake Palestine) is needed in the Western Subsystem in the 2030 decade to minimize risk of water supply shortages.
- Addressing reliability concerns and expansion in the Eastern Supply Subsystem by implementing previously planned projects can satisfy capacity needs and if completed by about 2030, can allow delay of a Western Subsystem WTP expansion and need for additional Western Subsystem water supply (Main Stem Balancing Reservoir) to about 2050.
- Increasing water demands in the southwest are driving the need for additional capacity as soon as possible, whether through delivery from the Southwest Pipeline or another alternative (e.g., connecting IPL water to the southwest portion of the system); there are current challenges with meeting water demands in the southwest and projections indicate the need to complete the Southwest Pipeline projects or an alternative in the 2030 timeframe.
- The potential for additional water conservation may allow further delay of water treatment capacity expansions.

8.6.4.2 RECOMMENDATIONS

As is common for large water supply, treatment, and distribution systems with wholesale customers like Dallas, capacity, water quality, and maintenance of system storage volumes and water pressure while minimizing water age presents several challenges. These factors are all important in considering infrastructure improvements, such as where to implement treatment capacity expansions, and the impacts on water distribution. In addition to implementing the recommended infrastructure improvements, it is recommended that Dallas take the following next steps to continue its approach to integrated, system-wide planning:

- Continue with planned projects per Table 8-8 including:
  - Bachman WTP and Elm Fork WTP improvements that will achieve reliable production capacities of 150 MGD and 330 MGD, respectively, within the next 5 to 7 years,
  - IPL Connection completed in 2030 decade,
  - Completion of Southwest Pipeline and related projects by 2030 to increase East Side WTP production capability to 470 MGD
  - Completion of East Side Expansion to 540 MGD with associated raw water conveyance system improvements by 2045,
  - Western Subsystem WTP expansion and Main Stem Balancing Reservoir, Pump Station, and Pipeline by 2045 to 2050, and
  - Neches Run-of-the-River or Lake Columbia infrastructure 2070.

- Assess implications of implementing the recommended water supply and treatment capacity infrastructure improvements on treatment plant and distribution system planning.
  - Complete additional water supply and water quality studies as recommended in Chapter 6 and 9.
  - Conduct additional study to confirm approach to a future Western Subsystem WTP Expansion and initiate planning; study to include:
    - Understanding of Elm Fork WTP capacity to handle expansion of 150 MGD or greater vs. alternative options,
    - Alternatives to convey future water supplies to Elm Fork WTP vs. alternative options, and
    - Impacts of WTP capacity expansion and point of entry to the distribution system on distribution system infrastructure needs, operations, and water quality.

This Page Intentionally Left Blank.

9 Conclusions and Recommendations

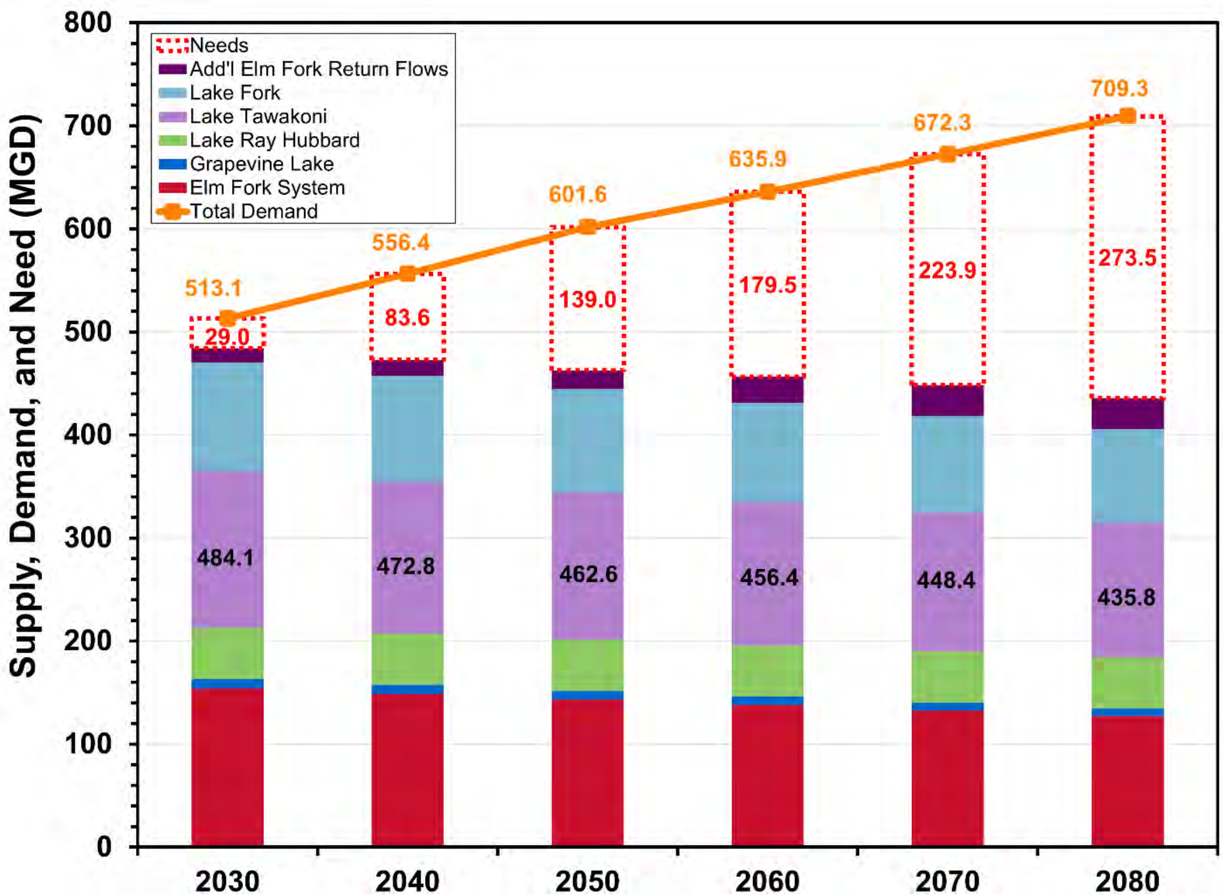
9.1 Summary

Dallas initiated the 2024 LRWSP effort in 2022 with goals of:

- Developing population projections for the City of Dallas using more detailed planning data than the Region C process,
- Developing a City of Dallas retail customer population projection tool,
- Evaluating the reliability of existing supply sources considering updated hydrological period of record, current and future sediment accumulation in reservoirs, and climate change,
- Developing updated demand forecasts for the City of Dallas retail customers using updated information on population, use, and conservation,
- Developing Dallas Customer Cities demands by relying on updated information from the 2026 Region C planning effort,
- Developing a water demand forecasting tool,
- Updating the Dallas RiverWare Model,
- Reevaluating recommended and alternative strategies from the 2014 LRWSP to confirm viability for inclusion as part of Dallas' 2024 Long Range Water Supply Plan,
- Evaluating interstate water supply strategies, stormwater supplies, and resiliency and operational strategies including aquifer storage and recovery (ASR) and riverbank filtration,
- Considering equity when evaluating strategies,
- Defining implementation steps for recommended strategies, and
- Identifying infrastructure improvements in the water production, raw water transmission, and distribution system that may need to be implemented sooner as a result of the strategies identified in the LRWSP.

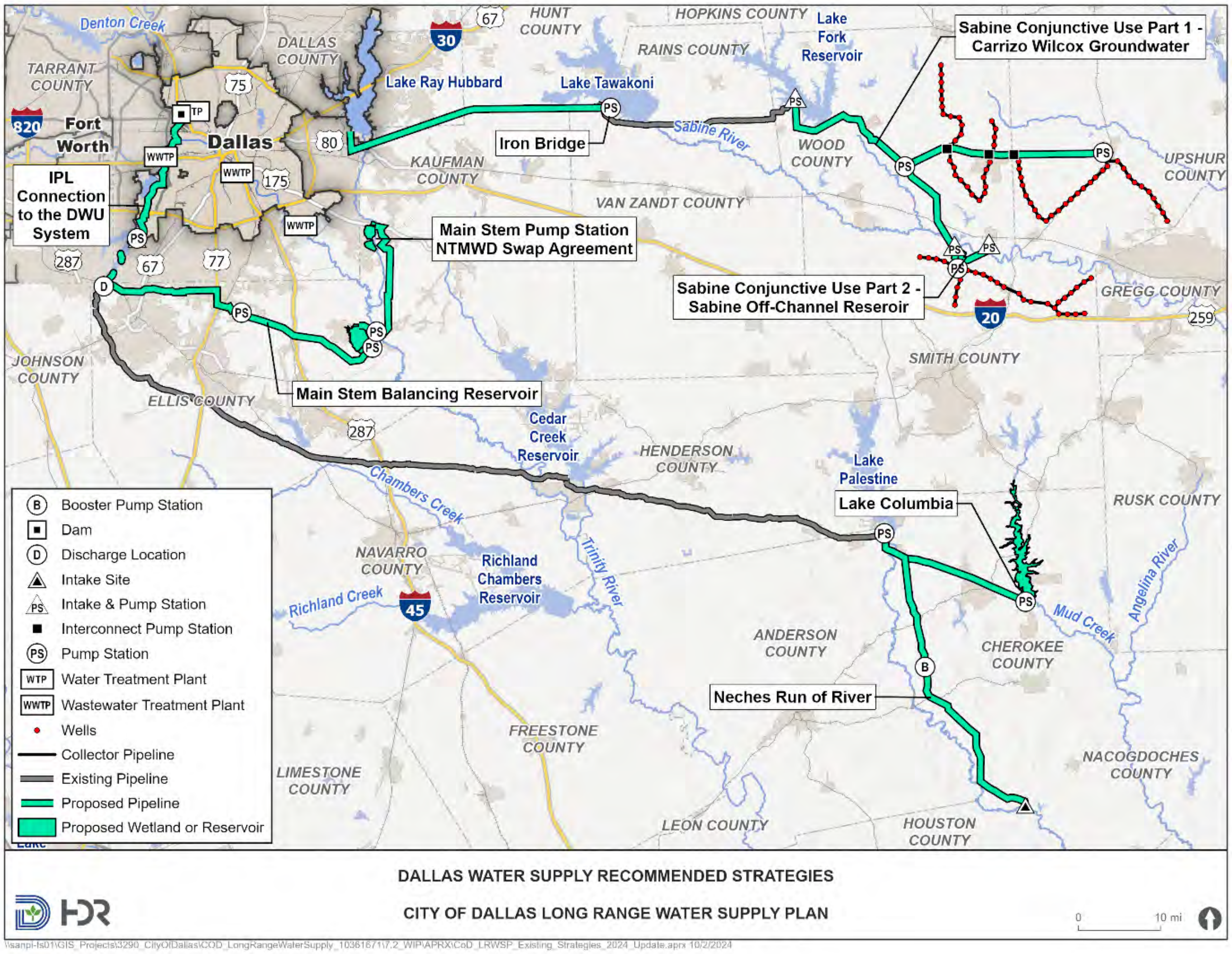
Dallas has identified a 53.7 percent increase in City of Dallas retail population and a 26.8 percent increase in DWU Customer Cities population over the 50-year planning period (2030 – 2080). With consideration of the projected population increase and potential drought conditions, water demand is expected to increase from 513.1 MGD in 2030 to 709.3 MGD by 2080, a 38.2 percent increase. Dallas' existing connected supplies are projected to decrease 10% over the planning period from reservoir storage losses from sediment accumulation and temperature increases from climate change. The supply decrease and demand increase results in a need of 29.0 MGD in 2030 and 273.5 MGD in 2080, shown in Figure 9-1.

Figure 9-1. 2024 LRWSP Supply, Demand, and Needs



Dallas has identified seven recommended water management strategies to meet the needs of its residents and customers through 2080. These recommended strategies rely heavily on conservation and reuse supplemented by the connection of new supplies.

Figure 9-2. 2024 LRWSP Recommended Strategies



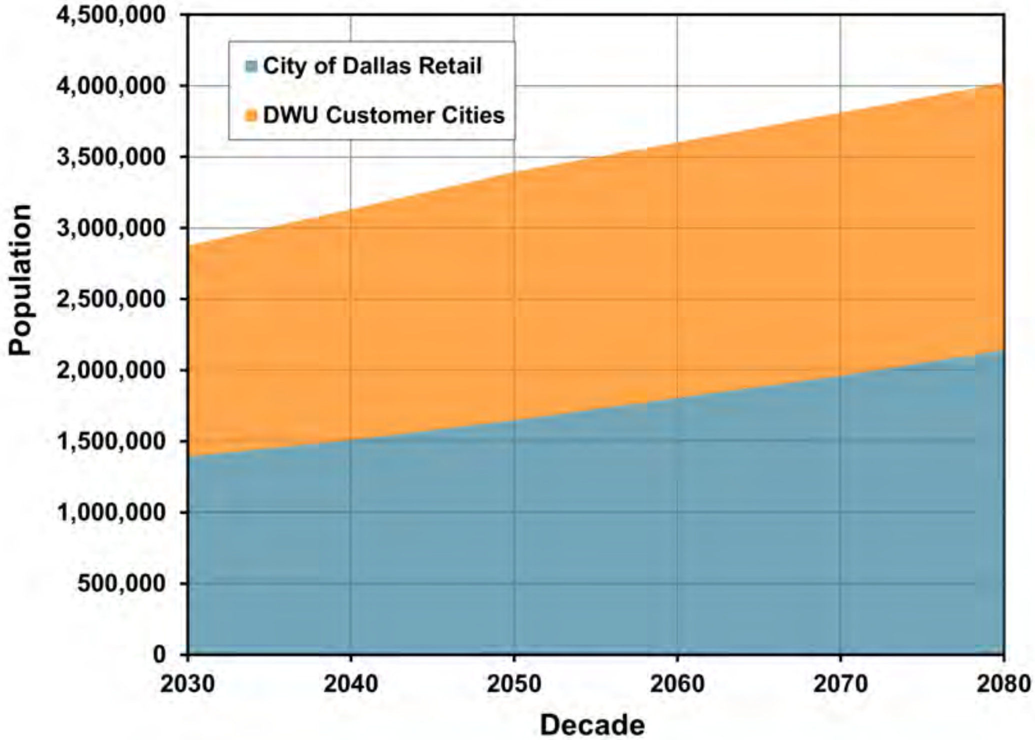
9.2 Findings and Conclusions

Findings and conclusions from the analysis and evaluations performed during the development of the 2024 LRWSP include the following.

- Dallas' service area is defined by the area served by its existing customers, both treated and untreated. The service area continues to adjust slightly as Dallas' customer cities extend their boundaries, or as contracts expire and are not renewed. Dallas occasionally receives requests from new wholesale customers for service that are considered on a case-by-case basis. The LRWSP does not recommend any new wholesale customers be added to the DWU system at this time.
- In 2030, the City of Dallas population is projected to be 1,393,479 and by 2080 Dallas' population is projected to increase to 2,142,389 which is an increase of 748,910 or 53.7 percent.

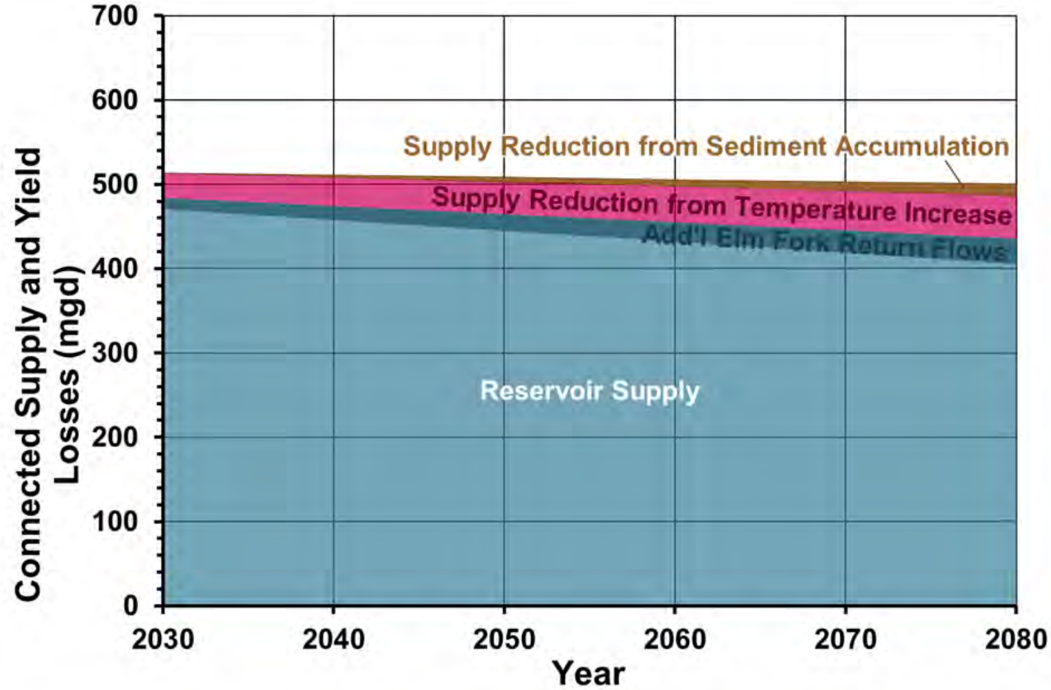
- In 2030, the total population of Dallas and its customer cities is projected to be 2,875,940, and by 2080 this population is projected to increase to 4,022,160 which is an increase of 1,146,220 or 39.9 percent.

Figure 9-3. Population Projections for City of Dallas and DWU Customer Cities



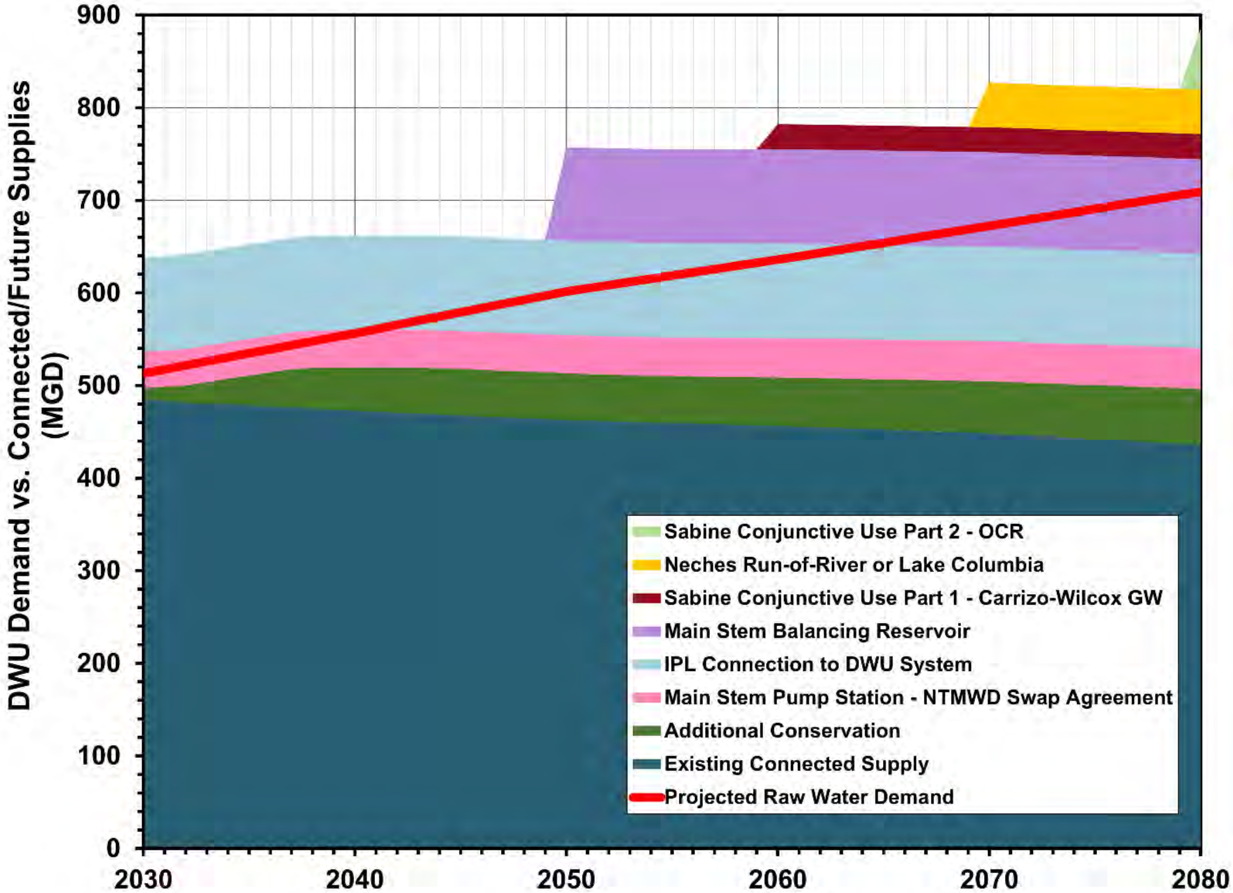
- Between 2030 and 2080 Dallas' existing supplies are expected to decrease from 484.1 MGD to 435.8 MGD due to sedimentation and increased evaporation from reservoirs as a result of expected increases in temperature. During this time, return flows available to Dallas are projected to increase.

Figure 9-4. Impacts from Sedimentation & Temperature Increase to Connected Supplies



- Dallas' demands are split almost evenly between the eastern and western subsystems with needs appearing sooner on the west due to limitations of existing firm supplies. The maximum demand split is assumed to be 55/45% within the distribution system and a 50/50% split used for comparison in the report.
- Additional raw water supply provided by Lake Palestine through the IPL project is needed early in the 2030 decade to minimize the risk of water supply shortages during droughts.
- Dallas' total rated water treatment production capacity is 900 MGD. Combined reliable water treatment capacity is currently about 785 MGD considering treatment and high service pumping limitations per the 2024 Water Production Facilities Strategic Plan (WPFSP).
- Treated water peak day demands are expected to exceed Dallas' reliable water production capacity of 785 MGD early on in the planning horizon, driving the need for implementation of projects identified in the WPFSP.
- Dallas has selected seven recommended and seven alternative strategies to meet future water supply demands to 2080. The recommended strategies and implementation timeline are shown in Figure 9-5.

Figure 9-5. Strategy Implementation Timeline for DWU Total System (comparing Demands and Supplies)



- The potential for additional water conservation may allow further delay of water treatment capacity expansions.
- Implementation of the recommended strategies on the schedule provided in the 2024 LRWSP allow Dallas to keep about an 18 percent supply buffer over the estimated demands, as shown in Table 9-1. By including this buffer, DWU is able to prepare for a drought worse than the historical drought of record. Further discussion on the potential effect of droughts worse than the drought of record can be found in Section 5.4.4.

Table 9-1 Strategy Implementation Timeline

Demand / Supply / Strategy	2030	2040	2050	2060	2070	2080
Current System						
Projected Raw Water Demand	513.1	556.4	601.6	635.9	672.3	709.3
Existing Connected Supply	484.1	472.8	462.6	456.4	448.4	435.8
Buffer / (Deficit)	(29.0)	(83.6)	(139.0)	(179.5)	(223.9)	(273.5)
Recommended Water Management Strategies						
Additional Conservation	13.1	46.6	50.6	52.3	56.2	60.5
Main Stem Pump Station - NTMWD Swap Agreement	39	40.4	41.2	42.5	43.3	44.2
IPL Connection to the DWU System	102	102	102	102	102	102
Main Stem Balancing Reservoir	-	-	100.8	102	102	102
Sabine Conjunctive Use Part 1 – Carrizo-Wilcox GW	-	-	-	27	27	27
Neches Run-of-River or Lake Columbia	-	-	-	-	48	48
Sabine Conjunctive Use Part 2 – OCR	-	-	-	-	-	66
Total Future System						
Supply From Recommended Strategies	154.1	189.0	294.6	325.8	378.5	449.7
Total Supplies	638.2	661.8	757.2	782.2	826.9	885.5
Buffer / (Deficit)	125.1	105.4	155.6	146.3	154.6	176.2
Percent Buffer of Total Supplies	**19.6%**	**15.9%**	**20.6%**	**18.7%**	**18.7%**	**19.9%**

- Dallas has coordinated with Region C so that the results from the 2024 LRWSP can be incorporated into the 2026 Region C Plan.

9.3 Recommendations

The following is a list of recommendations, or next steps, that Dallas should execute to implement the findings of the 2024 LRWSP. These recommendations are separated into three groups. The first group includes additional studies that are needed to provide Dallas additional information prior to fully implementing some of the strategies. The second group of recommendations includes permitting actions that Dallas should implement to secure water rights necessary for successful implementation of some of the strategies. The final group of recommendations is classified as strategy implementation and infrastructure improvement items that Dallas should move forward with to successfully implement the plan.

9.3.1 Additional Studies

The following studies and activities were identified during the development of the 2024 LRWSP and are recommended for Dallas's consideration:

- Dallas is currently evaluating delivery of IPL water to the Dallas system and these results should be incorporated into the final 2024 LRWSP.
- Dallas should initiate a Main Stem Balancing Reservoir permitting and feasibility study that includes:
    - amending Permit 12468 (Dallas' reuse water right) to include authorization for the storage reservoir,
    - performing a siting study for the main-stem balancing reservoir pump station considering bank stabilization, water level control and flooding issues,
    - preparing a water quality evaluation of the reservoir,
    - applying for any necessary 404 permits,
    - performing a reservoir site foundation (geotechnical) evaluation,
    - determining the need for a new Trinity River water control structure or improvements to an existing structure; and
    - initiate a land acquisition and maintenance program.
- Dallas should continue to partner with the UNRMWA on additional studies and permitting of a new strategy in the Neches River Basin. The final project permitted and pursued by UNRMWA could have a different configuration than the one identified here as part of the 2024 LRWSP Section 7.7 but would still serve as a recommended strategy for Dallas.
    - Develop an agreement with UNRMWA to establish what percentage of the project yield may be required to remain in the Neches River Basin to meet local demands.
- Dallas, on its own or in cooperation with other regional partners, should initiate a feasibility study of the Red River Off-Channel Reservoir (OCR) strategy to further evaluate the potential for that strategy to develop a large-scale reliable supply. This study would include analyses on water availability, Red River Compact issues, water quality and invasive species concerns, regional delivery options, and intake location issues.
- Dallas should continue to participate in the Sulphur River Basin Feasibility Study with other regional partners.
- Dallas should consider a feasibility study for the two-phase Sabine River Conjunctive Use strategy with Carrizo-Wilcox groundwater and diversions of Sabine River water into an OCR.
- Dallas should consider several feasibility studies to evaluate the remaining alternative strategies to identify the priority of these as backups to the recommended strategies.
    - Interstate supplies: Oklahoma, Arkansas, and Louisiana,
    - Lake Texoma Desalination,
    - Stormwater as a water supply,

  - Aquifer Storage and Recovery,
  - Toledo Bend West supply, and
  - Direct reuse with a formal evaluation of direct potable reuse to be compared to the indirect potable reuse options.

9.3.2 Permitting

Dallas should proceed with several permitting efforts identified in the 2024 LRWSP given the complexity of the current regulatory and permitting system for water rights. Suggested permitting activities include:

- Dallas should seek the required water right permit necessary for the Main Stem Balancing Reservoir. This could be a separate application or an amendment to the existing Dallas return flow permit.
- Dallas should work with the Upper Neches River Municipal Water Authority to submit an application for the Neches run-of-the-river water right.
- Dallas should continue to work with the Angelina Neches River Authority on the potential implementation of Lake Columbia and potential permitting next steps.

9.3.3 Strategy Implementation & Infrastructure Improvement

Several recommendations from the LRWSP should be considered by Dallas that do not classify as either an additional study need or a permitting action. These recommendations are included in the following list for Dallas' consideration.

- Continue to update the strategic water conservation plan to identify, fund and implement appropriate best management practices to achieve planned conservation savings.
- Continue to monitor and document savings achieved from conservation efforts.
- Annually perform a population estimate for the Dallas residents to track accuracy of 2024 LRWSP population projections.
- Develop a population model for each Dallas Customer City to track population projections against those in the 2024 LRWSP and perform a population estimate annually.
- Continue to track daily production by the WTPs to compare with historical totals to better understand demand trends under different climate conditions. Compare annual demands to projected demands in the 2024 LRWSP.
- Reassess population and demands in greater detail every five years due to the rapid population growth within the Dallas service area.
- Continue to coordinate with NTMWD on the implementation of Main Stem Pump Station Swap Agreement strategy.
- Continue with planned infrastructure projects discussed in Section 8, including:

  - Water Quality Improvements Programs,
  - Completion of Southwest Pipeline and related projects by 2030 to increase East Side WTP production capability to 470 MGD,
  - Bachman WTP and Elm Fork WTP improvements needed to achieve reliable treatment capacities of 150 MGD and 330 MGD within the next 5 to 7 years,
  - East Side WTP Expansion to 540 MGD with associated raw water conveyance system improvements by 2045.
  - Western Subsystem WTP expansion, Pump Station, and Pipeline by 2045-2050.
- Develop Strategy Implementation Dashboards to define and monitor the path forward and progress of the projects. Implementation dashboards will include timeline, triggers, steps, and potential CIP outlay.

Appendix A. Population Projection Model by the City of Dallas

The population projection model prepared for DWU is to be sent in a separate submission.

This Page Intentionally Left Blank

Appendix B.

Population and Municipal Water Demand Draft Projections for the 2026 Regional and 2027 State Water Plans

1. Population and municipal water demand projections overview

Municipal water demand projections are a function of population projections, baseline Gallons per Capita per Day ($GPCD_{base}$), and projected plumbing code savings. The following steps are involved in developing municipal water demand projections for Water User Groups (WUGs):

a) develop population projections,
b) determine $GPCD_{base}$ by WUG,
c) develop plumbing code savings projections by WUG, and
d) calculate municipal water demand projections.

Population projections and municipal water demand projections are aggregated by counties and Regional Water Planning Areas. The high-level steps are outlined here, while Sections 2 and 3 of this document go into more detail.

1.1 Foundational data and major assumptions

- Population projections are based on county-level projections from the Texas Demographic Center (TDC), which used migration rates between the 2010 and 2020 decennial Census to project future growth (Section 2.1).
- The Texas Water Development Board (TWDB) drafted WUG-level projections using the TDC's 1.0 migration scenario projections and provided 0.5 migration scenario projections for the planning groups' consideration.
- $GPCD_{base}$ values were drafted for each WUG (Section 3.1) and minimum GPCD values were imposed (Section 3.2).
- Projected plumbing code savings for each WUG assume passive water efficiency savings due to plumbing code laws related to residential toilets, showerheads, clothes washers, and commercial toilets and urinals. (Section 3.3). WUGs with high employment relative to the permanent residential population may have high projected plumbing code savings due the replacement of commercial fixtures.

1.2 Key changes from previous planning cycle's projection methodology

- The TWDB population projections for the regional and state water plans have always relied, initially, on county-level population projections from the TDC. In the past, the TWDB had altered the resulting regional plan population projections in certain counties – by holding them flat in future periods – to avoid projecting declining populations. For the 2026 Regional Water Plans (RWPs), the draft county population projections followed the trends projected by the TDC, including declines.
- Future savings from additional faucet and dishwasher replacements were not considered necessary for inclusion in the draft plumbing code savings projections for this current planning cycle. Based on the effective year of the relevant plumbing code standards and the useful life of

these items, the expected water efficiency savings by replacement and new growth would reasonably be fully realized by the first projected decade (2030).

2. Population

The population projection methodology is performed in two steps: first, projections at the county-level, and then, projections at the WUG-level.

2.1 County population projections

Draft county population projections are based on the TDC's 2022 county-level population projections.[1] Such projections are based on recent and projected demographic trends, including the birth rates, mortality rates, and net migration rates of population groups and defined by age, gender, and race/ethnicity. Population projections represent permanent residents, and not seasonal or transient populations. This method for developing population projections is known as the cohort component method and is performed by the TDC using a model.

The TDC generally develops county-level population projections under three migration scenarios:

- zero migration: no net migration (natural growth only),
- 1.0 migration: net migration rates of 2010 to 2020 ("full-migration scenario"), and
- 0.5 migration: 2010 to 2020 migration rates halved ("half-migration scenario").

While the TDC's projections extend to 2060, the 2027 State Water Plan requires projections to 2080. Therefore, the TWDB staff used the 1.0 migration scenario to extend the TDC's projections through 2080 and to develop WUG-level projections. Although, the TDC strongly recommends use of the half-migration scenario for long-term planning, the TWDB drafted population projections for all planning regions using one consistent scenario. For each county, the draft projection is based on the 1.0 migration scenario as the default, but the 0.5 migration scenario was provided through 2080 for Regional Water Planning Groups (RWPGs) to consider during the review process. The TWDB staff extended each region's projections to 2070 and 2080 using the region-level compounded annual growth rates (CAGR) from the 2050 to 2060 projections (see Table 1) and then sub-allocated to counties within the regions using the county's share of the region's decadal growth.

[1] Texas Demographic Center, 2022, Population Projections, https://demographics.texas.gov/Projections/2022/

Table 1. Extending the TDC's thirty-year population projections through 2080

	Sum of TDC 1.0 Migration Scenario Projections				Extend two decades using Region-specific CAGR				
Region	2030	2040	2050	2060	2050 to 2060 CAGR	2070	2080	2060 to 2070 CAGR	2070 to 2080 CAGR
A	397,160	405,244	408,658	409,696	0.03%	410,735	411,779	0.03%	0.03%
B	189,639	182,637	172,769	162,203	-0.63%	152,283	142,971	-0.63%	-0.63%
C	8,866,884	10,093,722	11,297,108	12,440,777	0.97%	13,700,226	15,087,176	0.97%	0.97%
D	824,990	847,410	859,530	868,815	0.11%	878,201	887,689	0.11%	0.11%
E	931,194	960,699	969,203	963,018	-0.06%	956,873	950,768	-0.06%	-0.06%
F	778,553	879,271	982,649	1,071,087	0.87%	1,167,487	1,272,561	0.87%	0.87%
G	2,703,905	3,074,453	3,481,252	3,913,803	1.18%	4,400,096	4,946,811	1.18%	1.18%
H	8,369,431	9,477,092	10,583,689	11,611,062	0.93%	12,738,163	13,974,676	0.93%	0.93%
I	1,100,376	1,103,143	1,093,467	1,077,850	-0.14%	1,062,457	1,047,284	-0.14%	-0.14%
J	129,683	130,134	130,196	131,285	0.08%	132,384	133,493	0.08%	0.08%
K	2,125,830	2,481,504	2,827,373	3,204,245	1.26%	3,631,353	4,115,392	1.26%	1.26%
L	3,525,104	4,110,775	4,738,184	5,424,749	1.36%	6,210,796	7,110,741	1.36%	1.36%
M	1,778,329	1,831,384	1,842,992	1,818,702	-0.13%	1,794,734	1,771,082	-0.13%	-0.13%
N	585,222	586,642	580,190	569,474	-0.19%	558,956	548,631	-0.19%	-0.19%
O	553,026	587,260	620,752	665,214	0.69%	712,862	763,921	0.69%	0.69%
P	53,556	55,843	57,772	59,678	0.33%	61,648	63,682	0.33%	0.33%

2.2 Water user groups

The regional and state water plans require population projections and municipal water demand projections for individual WUGs (31 TAC § 357.31(a)). Before projections can be developed, a list of municipal WUGs with associated data must first be created.

2.2.1 WUG criteria

Defined in the Texas Administrative Code (31 TAC § 357.10(43 A-E)), municipal WUGs are composites of public water systems, grouped by utilities, developed at the beginning of each regional water planning cycle. Per *First Amended General Guidelines for Development of the 2026 Regional Water Plans (Exhibit C)*, RWPGs reviewed and provided input on the draft WUG list for the 2026 RWPs. Municipal WUGs generally include:

- utilities providing more than 100 acre-feet of municipal water per year;
- collections of utilities with a common water supplier or water supplies (Collective Reporting Units or 'CRU'); and
- remaining public water systems and self-supplied population summarized as "County-Other".

For the 2026 RWPs, the draft municipal WUG list was developed by carrying over all municipal WUGs from the 2021 RWPs with active, community public water systems. Additional new WUGs were evaluated based on the utility water use meeting the criteria listed in 31 TAC § 357.10(43 A-E).

2.2.2 Historical WUG populations

The historical WUG populations are a critical step in developing WUG population projections. Following the development of the WUG list, the 2010 and 2020 population estimates were developed based on the decennial Census.[2] Public water system boundaries were gathered from the TWDB's Texas Water Service Boundary Viewer application and grouped by WUG. Using ESRI Geographic Information Systems, WUG boundaries were then overlayed with the Census Blocks and population was counted. Because some boundaries contain inaccuracies (e.g., water lines shown as boundaries instead of the actual service area of the water provider) self-reported population estimates from the TWDB Water Use Survey were cross-referenced to determine the final WUG population estimates. The sum of the WUG populations were reconciled to the decennial Census population count. The number of households per WUG were estimated using the 2020 decennial Census data by county and persons per household were then estimated using the previously calculated population.

2.3 Projection methodology

Projections for individual WUGs are developed by sub-allocating the population from the region-county projections to the WUGs. The methods of allocating future populations from the county total to the sub-county areas include:

- share of growth: applying the WUG's historical (2010 to 2020) share of the region-county's growth to future growth,
- share of population: applying the WUG's 2020 share of the region-county's 2020 population to the region-county's projected population each decade, and
- constant population: applied to military bases, universities, and other WUGs that are primarily group quarter population. Also, any WUGs that indicated buildout in the 2021 RWPs were held constant at or near their buildout population from the previous planning cycle.

Over a fifty-year planning period, it can be expected that WUGs may grow at different rates within counties, therefore, the share of growth method was prioritized; however, an extensive review was completed by the TWDB staff to ensure that the projected growth rate was in line with the historical growth. If the projected growth rate was not similar to either the WUG's historical growth rate or the region-county growth rate, then the share of population method may have been used. The share of population method maintains the WUG's 2020 proportion of the region-county population throughout the planning horizon. The sum of all WUG population projections within a region-county was reconciled to the total region-county projection prior to the finalization of draft projections.

3. Municipal water demands

Draft municipal water demand projections utilize the permanent residential population projections and a decade-specific per person water use volume for each WUG, including County-Other WUGs. GPCD represents the entire utility's water use (including residential, commercial, and institutional water use). For each municipal WUG, the initial baseline GPCD ($GPCD_{base}$) value minus the incremental anticipated plumbing code savings for each future decade was multiplied by the projected population to develop the municipal water demand projections (see Section 3.4 for the formula).

[2] U.S. Census Bureau, 2020, Decennial Census, P.L. 94-171 Redistricting Data, https://www.census.gov/programs-surveys/decennial-census/about/rdo/summary-files.html

3.1 Baseline Gallons per Capita per Day

For the 2026 RWPs, the baseline GPCDs represent historical 'dry-year' water use minus accumulated plumbing code savings ($GPCD_{base}$). The GPCD was drafted for WUGs by carrying over the GPCD from the 2021 RWPs minus estimated accumulated plumbing code savings. The GPCDs in the 2021 RWPs were carried over from the 2016 RWP and mostly represented the historically dry year 2011, although some WUG GPCDs in the 2021 RWPs were revised by the planning groups to use more recent 'dry-year' utility-based water use (2010 to 2015). Accumulated plumbing code savings were calculated using the annualized projected plumbing code savings from the 2021 RWPs for each WUG and subtracting from the carried over GPCDs (see Table 2). All new WUGs in the 2026 RWPs baseline GPCD were drafted using 2018 net water use from the TWDB Water Use Survey and estimated population from the U.S. Census Bureau.

Table 2. Calculating Baseline GPCDs for existing WUGs

2027 Entity Name	RWP21 $GPCD_{base}$	RWP21 GPCD Approx. Year	RWP21 PC Savings 2020	2010-2020 Per Year PC Savings	Number of years between $GPCD_{base}$ & 2020	GPCD minus Savings Accrued	New $GPCD_{base}$ (draft)
AMARILLO	211	2011	9.62	0.96	9	8.7	202
AUSTIN	162	2011	6.00	0.60	9	5.4	157
CORSICANA	214	2011	10.22	1.02	9	9.2	205
DALLAS	207	2015	9.14	0.91	5	4.6	202
LOWER VALLEY WATER DISTRICT	107	2010	10.86	1.09	10	10.9	96
SEGUIN	147	2012	10.04	1.00	8	8.0	139
SPRINGS HILL WSC	88	2011	9.49	0.95	9	8.5	79
ALBANY	258	2013	10.15	1.02	7	7.1	251
NORTH HUNT WSC	60	2011	0	0	9	0	60
RIVERSIDE SUD	64	2011	4	0.4	9	3.6	60

Historical GPCDs were provided for RWPGs consideration to revise the baseline GPCD. The historical GPCDs were developed annually and gathered for the 2026 RWP revision process. Each year, GPCD is estimated for each WUG through the Water Use Survey by:

a) calculating the net water use of each water system surveyed annually by the TWDB as total system intake volume minus sales reported by the water system to large industrial facilities and other public water systems plus volumes purchased by other surveyed entities,
b) summarizing the net use by WUG,
c) estimating population for the WUG using the U.S. Census Bureau's population estimates for the county, and
d) dividing the net use by the WUG's population and then dividing by 365 (number of days in a year).

3.2 Minimum GPCD values

When calculating the $GPCD_{base}$ or the projected per person water use values, the TWDB staff applied a minimum of 60 GPCD for each WUG. The minimum value of 60 GPCD is based on two studies: *Analysis of*

Water Use in New Single-Family Homes[3] and an internal TWDB report, *The Grass Is Always Greener...Outdoor Residential Water Use in Texas*, analyzing the percentage of Texas residential water used outside of the home.[4] The single-family home study researched the average indoor per person water use for:

- pre-1995 Homes (62.18 GPCD),
- standard new homes built after 2001 (44.15 GPCD),
- standard new homes retrofitted with high-water-efficient fixtures and appliances (39.0 GPCD), and
- new WaterSense homes built with the best available technology for water conservation (35.6 GPCD).

With the assumed replacement of fixtures and appliances over the next 50 years, the indoor per person water use of the standard new home retrofitted (39.0 GPCD) can be expected under existing standards. However, this is only indoor use and the single-family home study found that there was no statistical difference in outdoor water use between types of housing. The TWDB study of outdoor water use in Texas estimated that on average 31 percent of total residential water use is outdoor water use. Utilizing this average outdoor water use percentage (31 percent) and the indoor water use (69 percent) of 39 GPCD for retrofitted new homes produced a total residential GPCD of 56.5. While some municipal WUGs may remain primarily residential, any water use by commercial, institutional, and light industrial water users will contribute to the overall WUG's average GPCD. For this reason, the minimum baseline GPCD, as well as decade-specific projected GPCD (baseline GPCD minus projected plumbing code savings) was rounded to a value of 60 GPCD.

3.3 Plumbing code savings

Plumbing code savings may be referred to as water efficiency savings and are required to be considered in municipal demand projections per 31 TAC § 357.31(d). Plumbing codes are federal and state laws that mandate the efficiency of all new appliances and fixtures sold in retail stores. Plumbing codes result in passive water efficiency savings, as households naturally replace older appliances and fixtures without having to 'actively' seek more water efficient appliances and fixtures. The TWDB staff project plumbing code savings for each WUG for each decade in the planning horizon for the following fixtures and appliances: residential toilets, clothes washers, showerheads, and commercial toilets and urinals.

3.3.1 Plumbing code standards and parameters

Historical legislation (both state and federal) impacts the volume of water used within homes and businesses. Such legislation generally provided a maximum water use standard (per flush, per cycle, or per minute), as well as an effective date for when appliances and fixtures sold locally must meet that standard. Tables 3 and 4 summarize the effective years and the standards for each fixture and appliance included in the plumbing code savings projections. The assumed effective date for the first State of Texas

---

[3] *Analysis of Water Use in New Single-Family Homes*, 2011, Prepared by William B. De Oreo of Aquacraft Water Engineering & Management for The Salt Lake City Corporation and the U.S. Environmental Protection Agency.

[4] *The Grass Is Always Greener...Outdoor Residential Water Use in Texas*, 2012, Sam Marie Hermitte and Robert E. Mace, Texas Water Development Board Technical Note 12-01.

standards is 1995, which varies slightly from the effective date within the legislation, as allowances were included within the legislation for the sale of inventory stocks. For the purposes of calculating future plumbing code savings, the assumed effective date for the first standards is 1995. Whereas the other standards listed in Tables 3 and 4 correspond with the effective dates listed in each of the pertinent pieces of legislation or actual designation by EPA rule. Based on new research, the useful life of fixtures/appliances may be updated between planning cycles. Standards are measured in gallons per minute (gpm), gallons per flush (gpf), or gallons per cycle (gpc).

Table 3. State of Texas Plumbing Code Standards

Standards	Effective Year of New Standard		Useful Life	Included in 2026 RWP?	Included in 2021 RWP?
	1995[5]	2014[6]			
Faucets	2.2 gpm		15 years	No, benefits fully realized	Yes
Toilets	1.6 gpf	1.28 gpf	25 years	Yes	Yes
Showerheads	2.75 gpm	2.5 gpm	15 years	Yes	Yes
Urinals	1 gpf	0.5 gpf	25 years	Yes	No

Table 4. Federal Plumbing Code Standards

Standards	Effective Year of New Standard					2026 RWP Useful Life	Included in 2026 RWP?	Included in 2021 RWP?
	2010[7]	2011[8]	2012[9]	2015[10]	2018[10]			
Dishwashers	6.5 gpc		5 gpc			10 years	No, benefits fully realized	Yes
Front-load Clothes Washers (4.0 cubic feet)		38.0 gpc		18.8 gpc		12 years	Yes	Yes
Top-load Clothes Washers (4.5 cubic feet)		42.75 gpc		37.8 gpc	29.25 gpc	12 years	Yes	Yes

Two possible fixtures/appliances, originally included in the legislative efforts concerning plumbing codes,

[5] State of Texas Legislature, SB 587, 1991, 72(R) legislative session, https://capitol.texas.gov/MnuLegislation.aspx
[6] State of Texas Legislature, HB 2667, 2009, 81(R) legislative session, https://capitol.texas.gov/MnuLegislation.aspx
[7] EPA Water Sense, National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances, Sept. 29, 2008.
[8] U.S. Congress, Public Law 110-140, Energy Independence and Security Act of 2007, Dec. 19th, 2007.
[9] Federal Register, Energy Conservation Program: Energy Conservation Standards for Dishwashers, Vol. 77, No. 190 October 1, 2012.
[10] Office of Energy Efficiency and Renewable Energy, Department of Energy. Energy Conservation Program: Energy Conservation Standards for Residential Clothes Washers, May 31, 2012.

were not included in the 2026 RWP draft calculations. Kitchen and bathroom faucets as well as residential dishwashers were excluded as the timing of the latest effective plumbing code standards and the useful life combined to render little or no additional savings via replacement or new construction installations during the 2030 to 2080 planning horizon.

Draft 2026 RWP water efficiency savings projections also include savings within the commercial sector, a first for the regional water planning effort. Improvements in data availability and analysis methods allowed this first-time estimation for potential water savings due to replacement of commercial toilets and urinals at the WUG-level.

Water savings estimates that accompanied the water demand projections represent an estimation of the amount of water (average per person) that will be saved by the conversion to more water-efficient fixtures. Housing units built before the various standards came into effect will, over time, replace their old fixtures with the new water-efficient fixtures. In addition, construction of new homes or businesses with the more efficient fixtures/appliances will also contribute to the passive savings estimate, lowering the average GPCD as the proportion of more water-efficient fixtures/appliances within the WUG increases over time.

Prior to determining the WUG-level expected savings, the TWDB staff assembled additional data concerning the useful life of each possible fixture/appliance (assumed values in Tables 3 and 4) and updated all calculations concerning the impacts on GPCD when replacing one fixture/appliance with a given level of efficiency with a more water use efficient fixture/appliance. . After reviewing the water efficiency standards, the TWDB staff converted the water use per fixture and appliance into per person water use and estimated GPCD savings (Tables 5 and 6) before projecting utility-wide savings. Because there are multiple standards for each fixture and appliance, the TWDB staff developed GPCD savings for each standard and tracked replacement rates since 1995 (when the first plumbing code laws were enacted). Commercial toilets and urinals were combined and GPCD savings were calculated using the gender percentages from the Bureau of Labor Statistics[11] and average number of flushes per day times the number of days at work.

Table 5. GPCD Savings Parameters - Fixtures

Fixture	**GPCD Savings**		
	Pre-1995 Average Use to 1995 Standard	**Pre-1995 Average Use to 2014 Standard**	**1995 Average Use to 2014 Standard**
Showerheads*	13.0	NA	1.86
Toilets - residential	10.5	12.1	1.6
Toilets & urinals – commercial**	7.06	8.41	1.35
* Savings values shown assume 8 minutes per shower and 6.5 showers per person per week ** Savings values shown assume state-level gender employee proportions and 6 days/week use for commercial toilet and urinal use			

[11] Bureau of Labor Statistics, 2020, Geographic Profile of Employment and Unemployment, https://www.bls.gov/opub/geographic-profile/home.htm

Table 6. GPCD Savings Parameters - Appliances

Appliance	Key Assumptions	GPCD Savings					
		Pre-2011 Average Use to 2011 Standard	Pre-2011 Average Use to 2015 Standard	Pre-2011 Average Use to 2018 Standard	2011 Standard to 2015 Standard	2011 Standard to 2018 Standard	2015 Standard to 2018 Standard
Clothes Washers	Composite top and front loader, 75/25 percent split.[12] 300 cycles/year[13] and statewide average household size of 2.77 people per household.[2]	0.22	2.35	4.25	2.52	4.41	1.90
Savings shown here are an example. Average persons per household varies by WUG and thus actual savings will vary by WUG.							

3.3.2 Plumbing code savings projections methodology – residential

Individual models were developed for each of the fixture/appliance types to project the plumbing code savings for each WUG for 2030 to 2080. The TWDB compiles population data rather than housing data, so in calculating the estimates of the number of houses and less-efficient fixtures, population was used as a proxy for the number of houses at the time the law took effect and the projection of future houses. The 1995 population was estimated for each WUG in the 2026 RWPs and used as a benchmark to determine the potential average per capita water savings. The 1995 population (as a proxy for housing and fixtures) is assumed to have less-efficient fixtures, which will be replaced over time, lowering the WUG's average GPCD. The TWDB staff tracked which standards were likely to be adopted from 1995 to 2080 using the respective efficiency standard and useful life of the fixture/appliance. TWDB staff calculated the estimated water use without water efficiency standards in place and calculated the estimated water use with adopted standards in place and estimated the difference between the two to develop the savings for each WUG in each decade for each fixture/appliance. This yielded the marginal change in GPCD for each decade (per WUG). Because some WUGs' projected populations decline over time, the planned replacement of fixtures and appliances based on useful life could exceed the number of people (proxy for households) in a WUG, therefore, the TWDB staff scaled the replacement rates based on the number of people within a WUG in each decade. These measures corrected the possible adverse impacts on the projected plumbing code savings and were deemed reasonable to align fixtures and appliances with occupied houses.

3.3.3 Plumbing code savings projections methodology – commercial

Employment estimates were used as a proxy to project the replacement of commercial toilets and urinals

---

[12] U.S. Energy Information Administration, Appliances in U.S. homes in the South and West regions, 2020, https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%203.8.pdf
[13] EnergyStar, Clothes Washers, https://www.energystar.gov/products/clothes_washers

and to project average water efficiency savings gained for the WUG. Historical data for county-level population and employment for 2000 through 2020[14] was used to document the relationship between county-level population and employment. A two-way lookup table was derived with the percent change in employment based upon size classes for population for the WUG and the percent change in population for the WUG. Once the employment projections by decade were determined, similar GPCD savings calculations as those done for residential were implemented. A set of planned replacements was determined based upon the pattern of employment growth, which was then adjusted if the planned replacement exceeded the projected employment. The projected savings by the replacement of more efficient toilets and urinals in commercial businesses, while a function of employment within the utility, was calculated on a WUG-level per person basis. Therefore, WUGs with high projected employment relative to the number of permanent residents may have high projected commercial savings.

3.3.4 Plumbing code savings projections by WUG

Spreadsheets were used to project the plumbing code savings for the specific fixture or appliance, based upon the historical WUG population estimates and projected population or employment. The four types of fixtures or appliance GPCD savings projections were reviewed for accuracy, and then aggregated to determine the total expected plumbing code savings for each WUG. These projections were used to reduce the baseline GPCD ($GPCD_{base}$) (Section 3.1) over the planning horizon to determine WUG-level passive water efficiency savings, as shown in the formula in Section 3.4 and Table 7 below. Figure 1 below demonstrates how the projected impacts of plumbing code savings will decline over time due to the adoption of more efficient appliances and fixtures, until the adoption of the most efficient appliances and fixtures has taken place (estimated to be 2040, based on useful life and current plumbing code standards).

[14] U.S. Census Bureau, 2000, 2001, 2010, 2011, 2019, and 2020, County Business Patterns.

Figure 1. Projected Impacts of Plumbing Code Savings

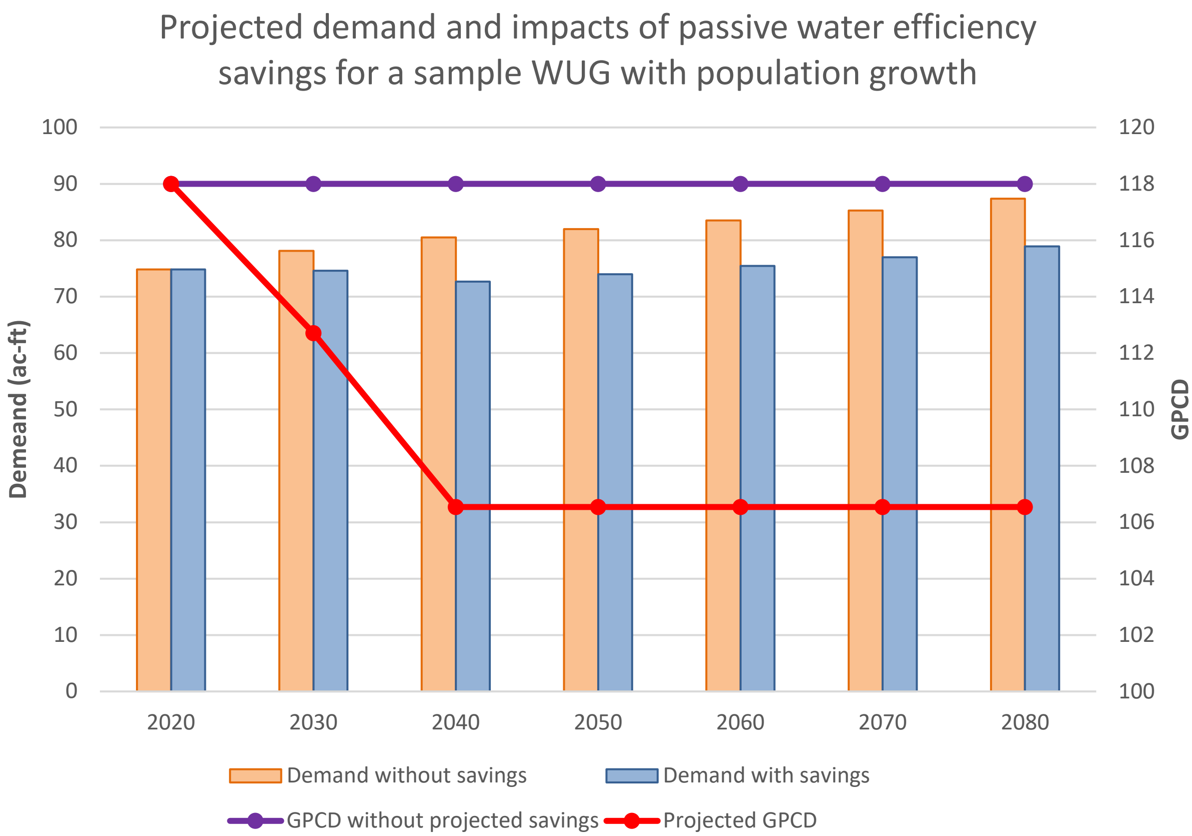


Table 7. Examples of Plumbing Code Savings by WUG

Entity Name	Baseline GPCD	Projected Plumbing Code Savings						Projected GPCD (rounded)					
		2030	2040	2050	2060	2070	2080	2030	2040	2050	2060	2070	2080
Abilene	163	4.75	5.37	5.37	5.37	5.37	5.37	158	158	158	158	158	158
Amarillo	202	4.83	5.46	5.46	5.46	5.46	5.46	197	197	197	197	197	197
Austin	157	4.90	5.49	5.49	5.49	5.49	5.49	152	152	152	152	152	152
Carthage	214	4.92	5.49	5.49	5.49	5.49	5.49	209	209	209	209	209	209
Cash SUD	103	4.37	4.87	4.87	4.87	4.87	4.87	99	98	98	98	98	98
Corpus Christi	173	4.68	5.36	5.36	5.36	5.36	5.36	168	168	168	168	168	168
Corsicana	205	4.65	5.21	5.21	5.21	5.21	5.21	200	200	200	200	200	200
Dallas	202	4.96	5.59	5.59	5.59	5.59	5.59	197	196	196	196	196	196
Los Fresnos*	60	0	0	0	0	0	0	60	60	60	60	60	60
Post Oak SUD	67	4.53	5.05	5.05	5.05	5.05	5.05	63	62	62	62	62	62

*Los Fresnos WUG baseline GPCD is already at 60, thus the minimum GPCD of 60 imposed throughout the planning horizon.

3.4 Municipal water demand projections

Municipal water demand projections are a function of population, baseline GPCD ($GPCD_{base}$), and projected plumbing code savings. Municipal water demand projections were developed for each WUG for each decade from 2030 through 2080 and then summarized by county and Regional Water Planning Area. The following formula was used to calculate municipal demands for each decade in acre-feet for each WUG:

$$\text{Projected Demand} = (\text{Population} * (GPCD_{base} - \text{PC Savings}) * 365) / 325{,}851$$

RWPGs may review and revise the WUG-level population projections, baseline GPCD, and projected plumbing code savings per criteria in *First Amended General Guidelines for Development of the 2026 Regional Water Plans (Exhibit C)*, thus revising the municipal water demand projections.

Appendix C. Population by Pressure Plane Methodology

This analysis was first completed in September 2023 using the most recent population data available. A technical memorandum describing the methodology and the results from that analysis has been included beginning on the following page.

After the completion of the first analysis, TXDC released updated population estimates. This analysis was updated using those population estimates for the baseline. A technical memorandum from March of 2024 provides the results from that analysis.

Technical Memorandum – ADMINISTRATIVE DRAFT

Date: September 8, 2023

To: Chang Lee, Dallas Water Utilities
Denis Qualls, Dallas Water Utilities
Cory Shockley, HDR Inc.
Darren Thompson, HDR Inc.

From: Zach Vernon, Maddaus Water Management Inc.
Lisa Maddaus, Maddaus Water Management Inc.
Michelle Maddaus, Maddaus Water Management Inc.
Tess Krestchmann, Maddaus Water Management Inc.

Title: DWU 2024 Long Range Water Supply Plan Population Forecast

1 INTRODUCTION

Maddaus Water Management (MWM) is working with Dallas Water Utilities (DWU) and HDR Inc. to complete the population and water demand forecasts for DWU's 2024 Long Range Water Supply Plan (LRWSP). This technical memorandum presents the background, approach, and results used to generate 2030-2080 population forecast estimates.

Details provided in this memorandum include the population forecast modeling approach using a custom Microsoft (MS) Excel-based tool that was created using the best available data sources. A land use-based GIS analysis provided parameters used in the tool, producing estimates for a baseline forecast and three potential planning scenarios. The findings were presented during a collaborative workshop, and further reviewed by DWU, HDR, Dallas Planning and Urban Design (DPUD), and the Texas Water Development Board (TWDB). The revised findings are presented in this memorandum.

1.1 Background

DWU operates one of the largest drinking water supply systems in the U.S., serving more than 2.4 million City of Dallas and wholesale customers. Continued population growth drives the need for additional water supply. DWU completed a comprehensive plan in 2014 and is now validating and updating previously identified strategies to deliver the Long Range Water Supply Plan.

The timing of the LRWSP population forecast coincides with development of TWDB's 2026 Regional Water Plan draft population estimates[1], released in May 2023. DWU coordinated with TWDB to incorporate the LRWSP forecast estimates for Dallas into the Regional Water Plan for Region C. Note that the LRWSP forecast covers the DWU retail service area. Estimated populations for customer cities will be sourced from TWDB's Water User

[1] "2026 Regional Water Plan DRAFT Municipal Demand Projections.", Texas Water Development Board, 2023, twdb.texas.gov/waterplanning/data/projections/2027/municipal.asp

Group projections, or, if available, directly from any customer cities that are generating custom population estimates.

1.2 Overview of Population Forecast Model Approach

The Population Forecast Model (Forecast) is implemented using a custom Excel-based tool that includes parameter settings, underlying data, and calculations visible in a model dashboard and supporting worksheets. The dashboard displays changes to the Forecast output in real-time, as parameters are modified, and compares the population projections to the most recent population estimate and projections from TWDB and the North Central Texas Council of Governments (NCTCOG). A population results table also provides real-time population estimate updates based on the selected settings. Note that a substantial data inventory and research effort (outlined in Section 2) preceded the development of the Forecast, including the generation of enhanced GIS layers created by filtering and combining land use data with housing, population, and zoning characteristics.

The Forecast offers transparency and customization by allowing users to access the underlying data and formulas. The main settings are presented in the Excel-based interface, enabling adjustments to specific parameters such as population pressure, population mix (e.g., Single-family residential, Multi-family residential etc.), or the number of new builds. A diagram illustrating the modeling workflow, which is covered in Section 3, is shown in Figure 1 below. More information about tool functionality, data update procedures, and scenario-based modeling is available in the training videos provided by MWM alongside this Excel-based tool.

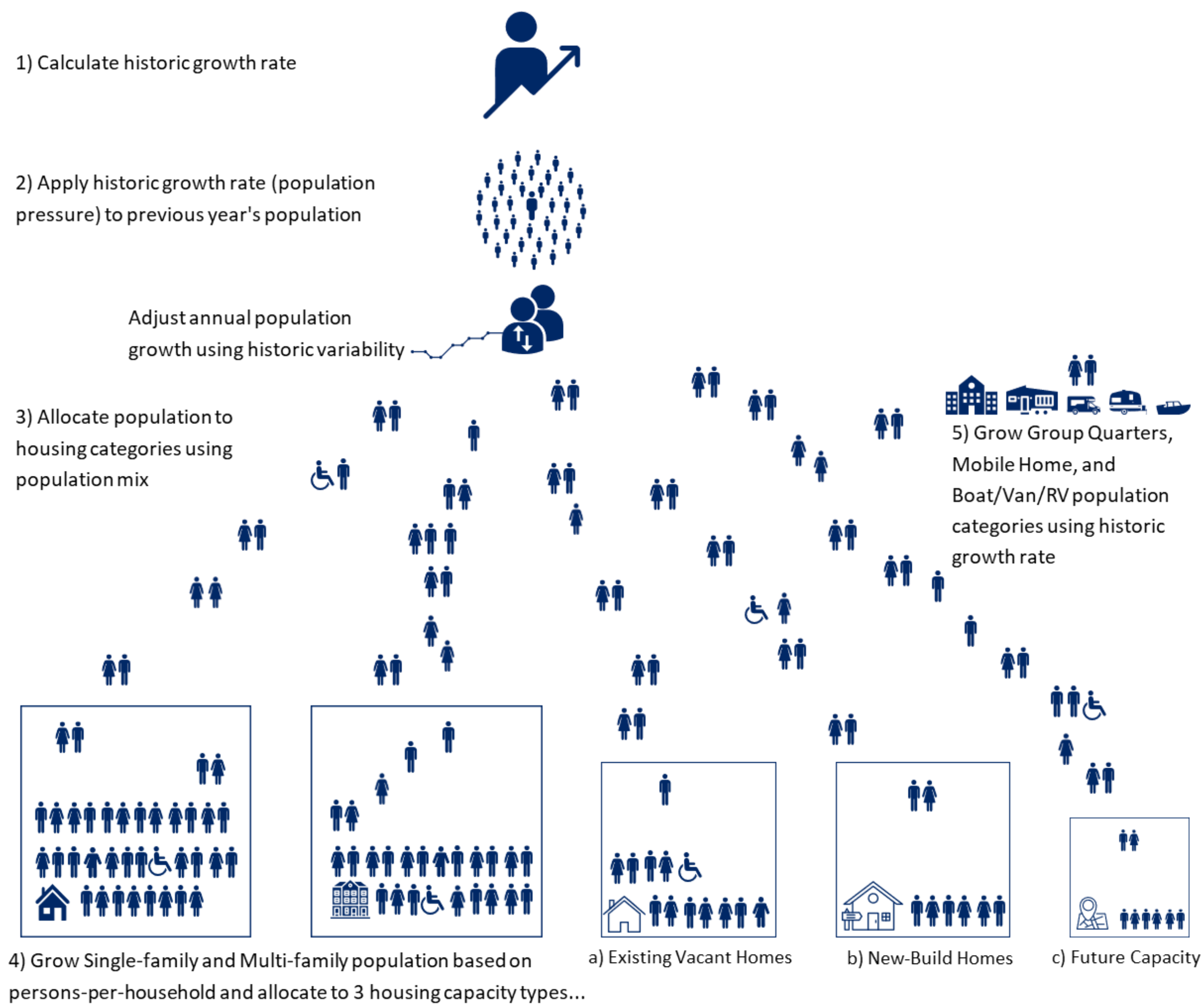


Figure 1. Population Forecast Methodology Overview

2 DATA INVENTORY AND MODEL INPUTS

This section provides an overview of the primary data inputs to the Forecast. Data was researched to identify the best-available datasets and inputs to the population model and were obtained from the following sources:

- Dallas Water Utilities
- Dallas Planning and Urban Design
- Texas Water Development Board
- U.S. Census Bureau
- North Central Texas Council of Governments
- Texas Demographic Center
- Texas A&M University's Real Estate Research Center

The datasets used in this planning effort are presented in order of the workflow used to generate the Forecast. Maps of GIS datasets not directly presented as figures within the memo are available in *Appendix A: Supporting Maps*.

2.1 Boundary Data

The boundary datasets considered in this analysis were the 2023 distribution system Pressure Zone boundaries provided by DWU[2] and the 2020 City of Dallas boundary from the U.S. Census Bureau. DWU Pressure Zone boundaries are assumed to represent the overall Service Area boundary for DWU. The alignment of both boundary files was considered and quantified to determine whether the DWU Pressure Zone boundaries aligned with the Census boundary for Dallas. If so, subsequent modeling steps could directly incorporate Census data for Dallas as inputs without performing additional processing (i.e., generating area-weighted estimates). Fortunately, the alignment is very good and only ~1.5 square miles (or ~0.4% of the service area) is not captured by the DWU / Census boundary overlap. Larger areas were inspected and none contained visible development (based on 2023 Maxar aerial imagery). A comparison map is shown in *Appendix A: Supporting Maps*.

Key finding: Direct use of unmodified Census data for the City of Dallas as a modeling input was appropriate thanks to 99.6% alignment with DWU Pressure Zone boundaries.

2.2 Historic Population and Housing Data

Historic population data was obtained from both the U.S. Census Bureau's American Community Survey (ACS)[3] and the Texas Demographic Center (TXDC)[4] for 2011-2022. The two datasets were compared to determine if the same population trends were present, and to help select which dataset to use as the primary input for total population. A comparison chart is shown in Figure 2 below. Both datasets demonstrate a period of negative growth from 2020-2022, which reflects the impact of the COVID-19 pandemic. ACS data on housing units, vacancies, and population mix by housing type were also used as model inputs; no comparison to TXDC was necessary as this data is unavailable from the TXDC. Specific ACS tables used were: 1) B25024: Units in Structure, 2) B25032: Tenure by Units in Structure, and 3) B25033: Total Population in Occupied Housing Units by Tenure by Units in Structure.

Key finding: TXDC data was selected as the primary input for total population based on DWU feedback since the data aligns well other sources, is produced every six months, and incorporates localized datasets/knowledge. ACS data provided detailed information on housing, vacancies, and persons-per-household.

---

[2] Received from Paul Sill (DWU GIS Manager) in March 2023 as feature class "System_Areas\PressureZone" in geodatabase "Maddaus_DWU_Service_Areas".
[3] "Census Bureau Data." United States Census Bureau, U.S. Department of Commerce, 2023, data.census.gov/
[4] "Texas Demographic Center." Texas Demographic Center, Texas State Data Center, 2023, demographics.texas.gov/

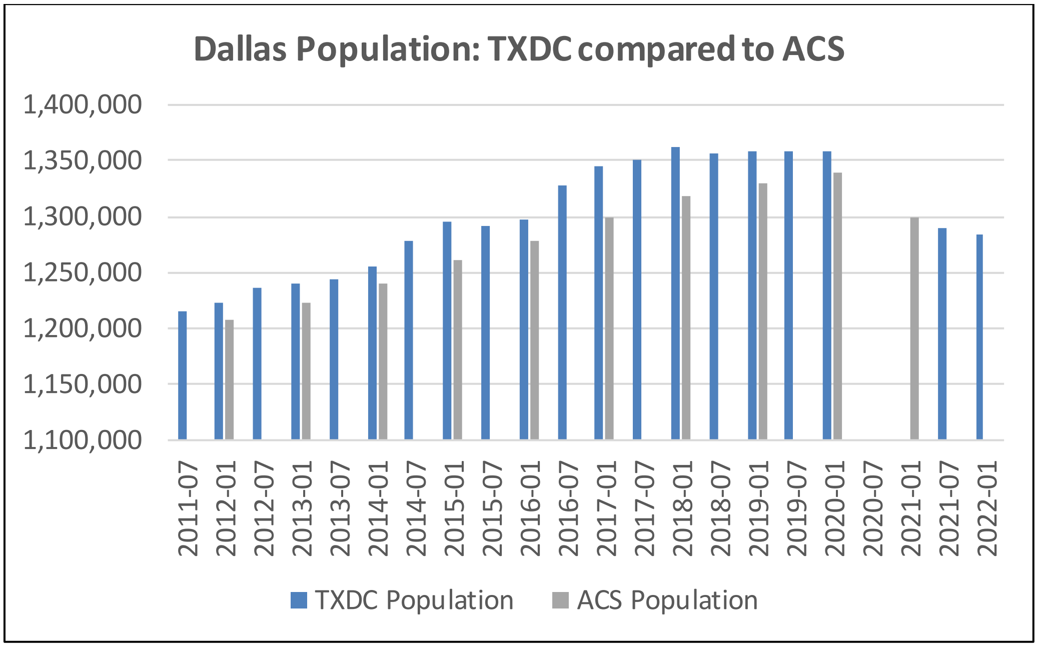


Figure 2. Comparison of Texas Demographic Center (TXDC) and American Community Survey (ACS) data on Dallas population from 2011-2022

2.3 Land Use Capacity Data

The primary data input for current land use capacity was the North Central Texas Council of Governments (NCTCOG)'s 2020 Land Use Inventory[5]. NCTCOG processes data from county assessor files to create a set of regionally standardized land use classes and definitions. There are a total of 27 land use categories in the 2020 inventory ranging from residential types to industrial and park uses; this population forecast model incorporates the following six land use categories: Single-family, Multi-family, Group Quarters, Mobile Homes, Parks/recreation, and Vacant. A map of the NCTCOG Land Use data is shown in Figure 3, below.

[5] "2020 Land Use." NCTCOG GIS Open Data, North Central Texas Council of Governments, 2023, data-nctcoggis.opendata.arcgis.com/datasets/NCTCOGGIS::2020-land-use/explore

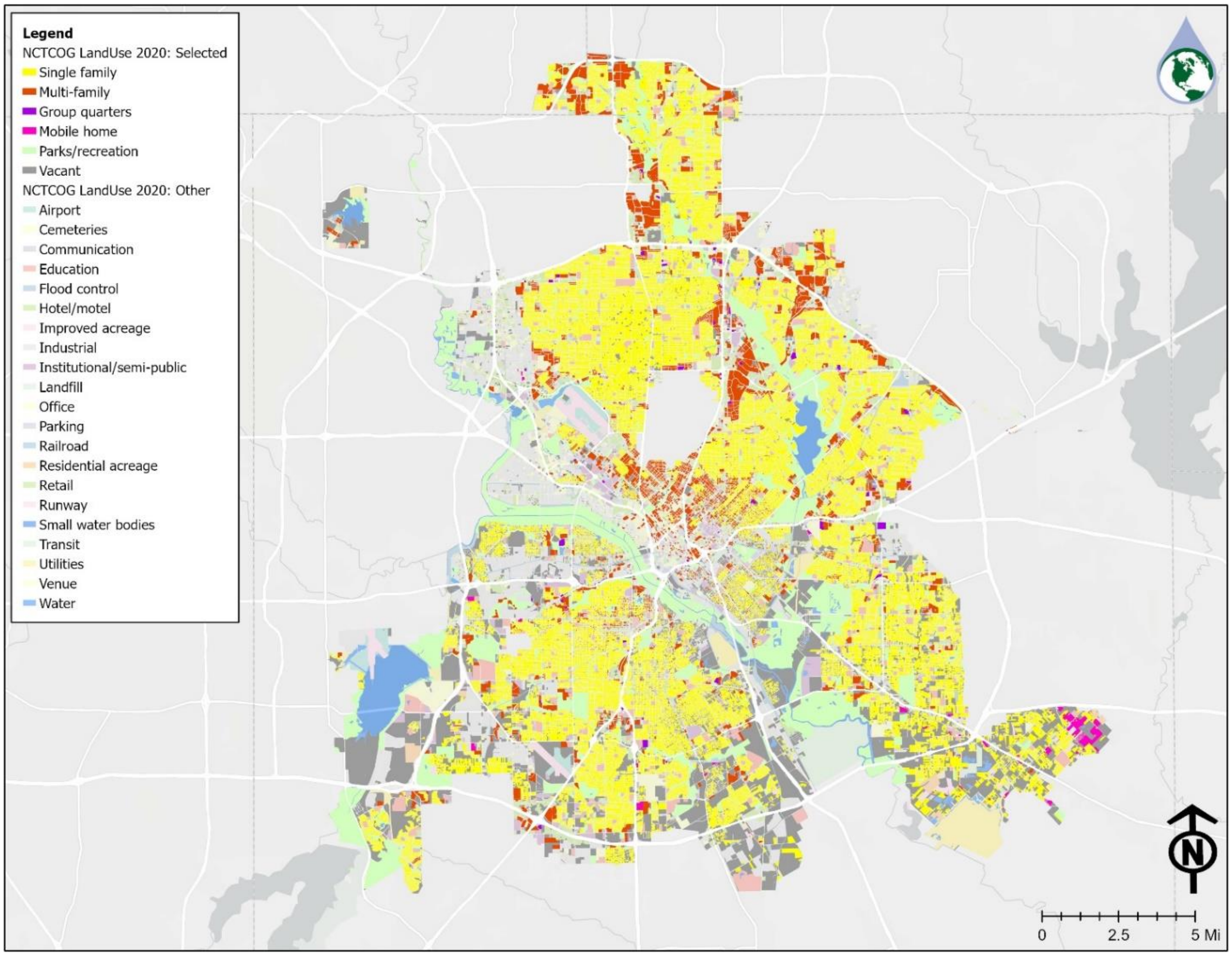


Figure 3. NCTCOG Land Use boundaries with selected Forecast categories (Residential categories, Parks/recreation, and Vacant) highlighted

ACS Population by housing type at the Block Group level was then assigned to NCTCOG land use areas using a categorical crosswalk. NCTCOG documentation on the land use inventory[6] was reviewed to determine which Census categories should be allocated to each land use type, and if any Census categories would need to be split into multiple NCTCOG categories (and vice versa). Fortunately, the land use categories in NCTCOG are perfectly aligned with Census housing categories, which allowed for direct allocation of Census block group data (housing units, vacancies, etc.) down to the parcel level. The original Block Group population data is shown in Figure 4, while the allocated population (from Block Group to Land Use area) is shown in Figure 5.

Key finding: Relevant NCTCOG Land Use categories have a 1-to-1 alignment with Census housing categories, so direct allocation between the two datasets was possible and was applied by allocating Census Block Group data on population mix, housing units, and vacancies to NCTCOG land use areas.

6 "2020 Land Use Inventory." North Central Texas Council of Governments, September 2022, rdc.dfwmaps.com/MethodologyDocs/NCTCOG%202020%20Land%20Use%20Description.pdf

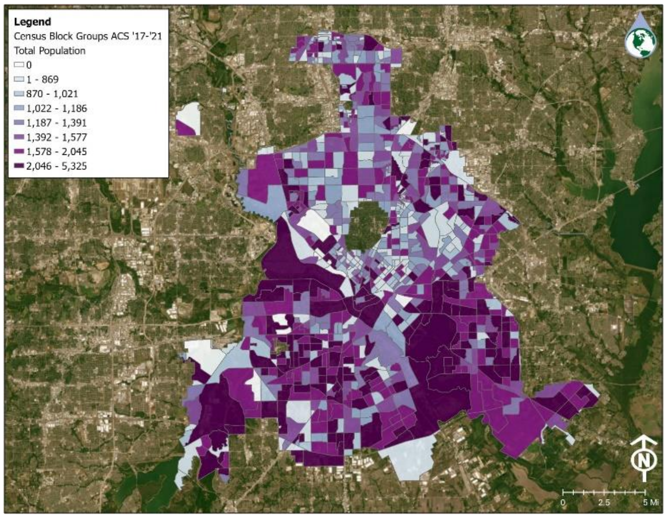


Figure 4. Block Group Population from the 2021 5-year ACS

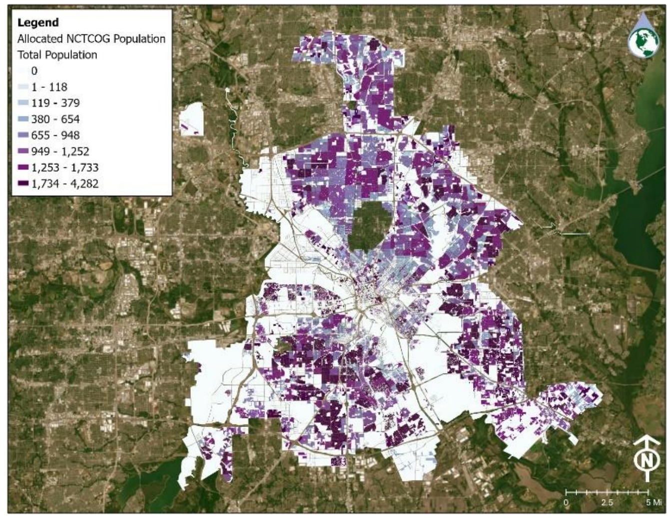


Figure 5. 2021 5-year ACS Population allocated to 2020 NCTCOG Residential Land Use areas

2.4 Future Development Data

Housing data from the most recent 5-year ACS (2017-2021) provided the current capacity based on total vacant units, differentiated by Single-family and Multi-family. Dallas Base Zoning (Zoning)[7] data was used to define future population capacity for vacant and underdeveloped areas currently zoned as residential. Dwelling units per acre (DU/acre) data from the Zoning codes was compared to the existing DU/acre to determine which areas have potential future additional population capacity. The Forecast assumes maximum development capacity in currently vacant areas where multiple DU/acre values are possible. This occupancy capacity is defined for all areas currently zoned as residential and is shown in Figure 6.

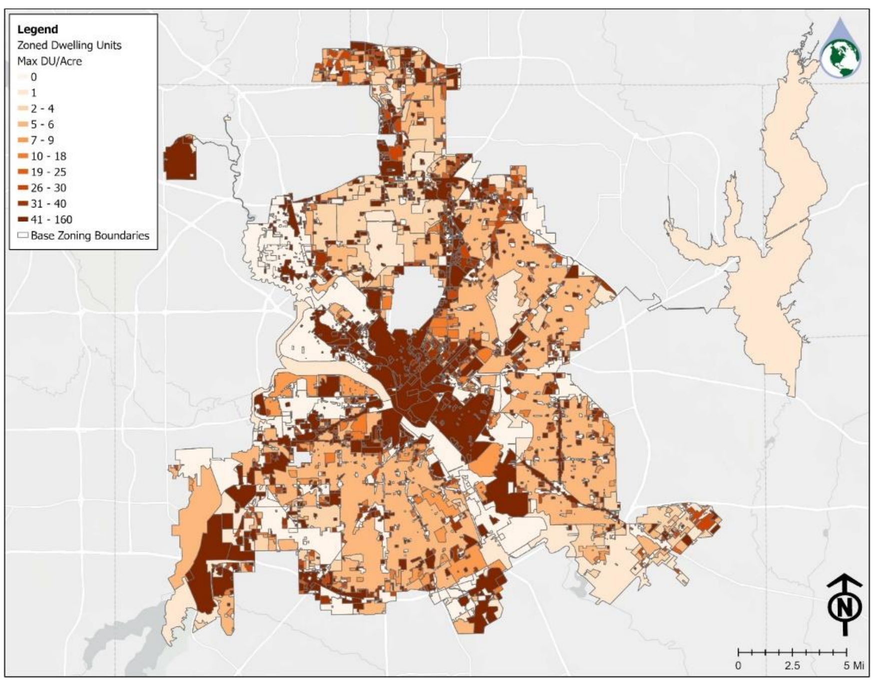


Figure 6. Dallas Base Zoning Capacity in Dwelling Units per Acre (DU/Acre)

[7] "Zoning Districts." City of Dallas, 2023, dallascityhall.com/departments/sustainabledevelopment/planning/Pages/zoning-districts.aspx

Additional future capacity was defined based on the ForwardDallas Place Type (Place Type)[8] layer from Dallas Planning and Urban Design (DPUD). The Place Type layer is a GIS-based representation of over 100 local plans and reflects the vision for future land uses, development, urban design features, transportation, and open space amenities for different areas within the City of Dallas. The Place Type layer was filtered to identify additional future residential development in areas that are not currently zoned as residential. A DU/acre value was assigned to represent future occupancy capacity, again assuming maximum occupancy for areas where multiple DU/acre values are possible. Maps displaying the extent and DU/acre of future Place Types are available in *Appendix A: Supporting Maps*.

Future development counts were generated based on a 10-year average of historic building permit data obtained from Texas A&M University's Real Estate Research Center[9], split into Single-family vs. Multi-family units. Permit counts were then adjusted based on Housing Starts data from the Census Survey of Construction. Based on 2012-2022 averages for the Census "South" Region (which includes 16 southern states in the U.S.), 98% of permitted Single-family units were constructed and 82% of permitted Multi-family units were constructed. The Forecast applies these adjusted counts when estimating annual new build units for both current residential zoning and future Place Type.

Key finding: Data representing future development capacity was researched and applied as Dwelling Units/Acre for residential areas identified by both the Dallas Base Zoning layer and ForwardDallas Future Place Types. The volume of new development was generated based on 10-year average Single-family and Multi-family building permit counts from Texas A&M's Real Estate Research Center, adjusted based on housing starts data from the Census Survey of Construction.

[8] "Place Types and Land Use." Dallas Planning and Urban Design, 2023, dallascityhall.com/departments/pnv/Forward-Dallas/Pages/Placetypes_LandUse.aspx

[9] "Texas Real Estate Research Center." Texas Real Estate Research Center, Texas A&M University, 2023, recenter.tamu.edu/

3 FORECAST METHODOLOGY

This section describes the methodology used to generate the Forecast, including a specific look at the population pressure calculations and other parameters selected for the baseline forecast. Broadly, the Forecast is performed by applying population pressure to both current and future housing capacity and filling vacancies based on Forecast parameters, as illustrated in Figure 7, and described in the steps below.

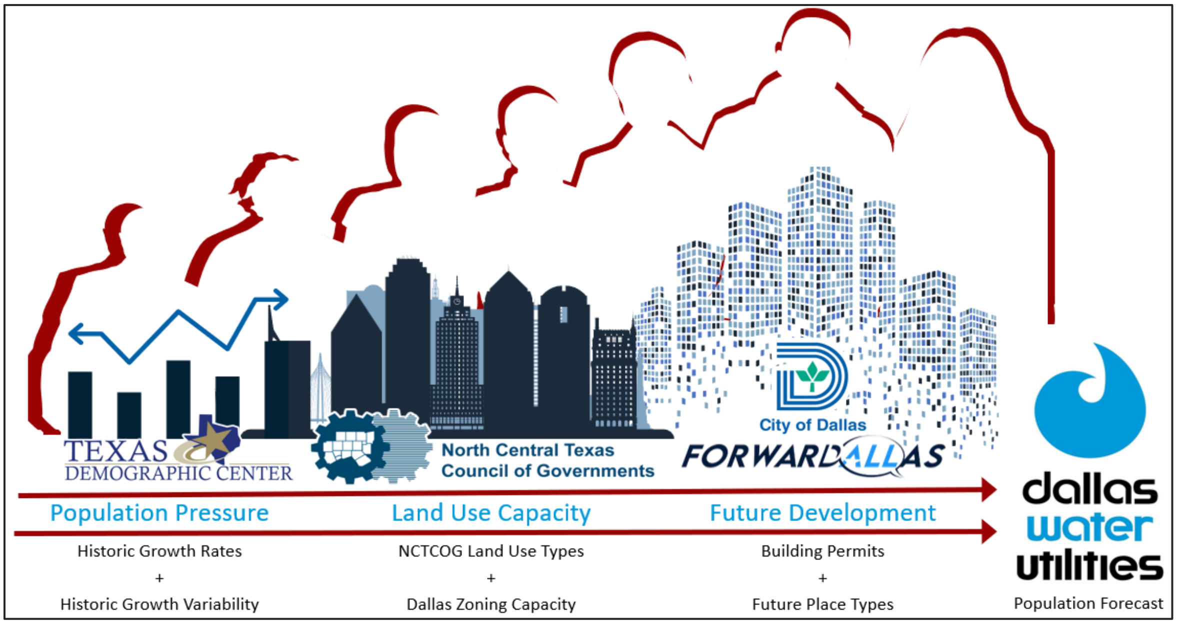


Figure 7. Generalized population forecast modeling workflow and data inputs.

3.1 Population Pressure

The growth rate from historic population trends was used to determine the volume of potential population growth in future years. This analysis considered several historic population trends and the associated annualized growth rates as shown in Table 1 below. Population growth from 2012-2019 for the City of Dallas was 11% overall based on TXDC population data, which equates to an annualized growth rate of 1.5%. Taking into account, and including, COVID-impacted years 2020-2022, the annualized population growth rate decreases to 0.48%. Highlighted cells contain the annualized growth rates of 1.50% and 0.48% that were modeled in the High Pressure and Baseline forecast scenarios, respectively.

Population Growth Rates		
Time Period	**% Growth**	**Annualized Growth**
7 Year (2012-2019)	11.0%	**1.50%**
10 Year (2012-2022)	4.9%	**0.48%**
5 Year (2017-2022)	-4.6%	-0.93%
3 Year (2019-2022)	-5.5%	-1.86%

Table 1. Population growth rates from 2012-2022 Texas Demographic Center data

3.2 Forecast Methodology Steps

The Forecast methodology is described in the following five steps, which include examples from the parameters selected for the baseline forecast.

1) Calculate various historic population growth rates and select one to apply as population pressure, as described in section 3.1. For example, the baseline forecast scenario uses an annual growth rate of 0.48% annualized growth, as calculated from the population growth observed from 2012-2022.

2) Apply the population pressure (annual growth rate) to the previous year's population to calculate the total population volume to be allocated annually. To address the non-linearity of population growth over time, historic growth variability was calculated from available recent data (2010-2021) and injected as artificial "noise" into the annual population projections. This variability is included in the model to account for year-to-year fluctuations in population growth. Historic growth variability is randomized within the +/- range defined by model parameters and applied to the total to determine the annual population growth. For example, a variability of ±7,313 people was calculated based on population growth variability calculated from 2010-2021 ACS data.

3) Allocate annual population growth rate to individual housing categories using the percent population mix (population profile) as defined by model parameters. For example, the baseline model uses the population mix from the most recent 5-year ACS (2017-2021), as shown in Table 2, to allocate total population to the individual housing categories.

Baseline Population Mix	
Single-family	56.19%
Multi-family	40.94%
Group Quarters	1.23%
Mobile Home	1.63%
Van, Boat, RV, etc.	0.02%

Table 2. Population Mix used in Baseline forecast, based on 5-year ACS data (2017-2021)

4) Add population volumes for each housing category based on available housing units and persons-per-household (PPH) for each category. Population is allocated unit-by-unit based on the PPH for each housing category, as governed by Forecast parameters. For example, the baseline model uses a PPH of 2.93 for Single-family units from the most recent 5-year ACS (2017-2021). Population is allocated to (a) currently vacant housing units first, and then (b) new-build housing units based on the DU/Acre for current residential zoning from Dallas Zoning and NCTCOG land use types, and lastly to (c) future new-build housing units for new residential areas from ForwardDallas Place Types.

    a. Existing Vacant Units Method: population is first allocated to current vacant housing units defined by the most recent 5-year ACS (2017-2021), split into vacant Single-family and vacant Multi-family. Approximately 74.5% of this capacity is made available for population growth each year, based on the 2022 percentage of population moving into existing units (85.2%) in Dallas, as reported by Housing and Urban Development's (HUD)'s American Housing Survey (AHS) data. The 85.2% was further reduced based on 10-year average vacancy rate (10.7%) from ACS data. This capacity category is available for all years of the forecast and is increased each year based on unoccupied new builds from the other two methods presented next.

    b. Current Zoning New Build Method: new build counts were based on 10-year residential property growth averages from the Texas A&M Real Estate Research Center, split into Single-family and Multi-family and reduced based on the estimated percentage of issued permits that were constructed. Approximately 4.1% of this capacity is made available for population growth each year, based on the 2022 percentage of population moving into new build units (14.8%) in Dallas, as reported by Housing and Urban Development's (HUD)'s American Housing Survey (AHS) data. The 14.8% was further reduced based on a 10-year average vacancy rate (10.7%) from ACS data. This capacity category is available for all years of the forecast.

c. Future Capacity Method: as with the Current Zoning Method, new build counts were based on 10-year averages from the Texas A&M Real Estate Research Center, split into Single-family and Multi-family and reduced based on the estimated percentage of issued permits that were constructed. Approximately 4.1% of this capacity is made available for population growth each year it is available, based on the 2022 percentage of population moving into new build units (14.8%) in Dallas, as reported by Housing and Urban Development's (HUD)'s American Housing Survey (AHS) data. The 14.8% was further reduced based on a 10-year average vacancy rate (10.7%) from ACS data. This capacity category is available based on the Start Year parameter in the model. All forecast scenarios, including the baseline, use 2040 as the Start Year based on insight from DPUD staff, which means that population is not allocated to these areas until 2040. Note that existing vacant units and new build opportunities from current zoning support the population growth based on the estimated population pressure until at least year 2040.

5) Grow the smaller population categories based on the annual growth volume calculated during step 3 above, where the percent population mix was applied to total population to allocate the overall growth to individual categories. The smaller population categories (Group Quarters, Mobile Homes, and RV/Van/Boat) are not governed by the three capacity methods described previously and are instead increased based on the population profile and historical annual growth rate, described in steps 1 and 2 above.

3.3 Forecast Refinement and Review Process

Baseline forecast parameters and values were developed by MWM and refined through a series of weekly calls with HDR and DWU staff. Draft results, including a discussion of data inputs and model parameters, were presented at a Population Forecast Workshop on June 8th, 2023, led by MWM at Dallas City Hall and attended by approximately 13 staff from MWM, DWU, Dallas Planning and Urban Design (DPUD), and HDR. Participants provided feedback on the Forecast results, model parameters, and provided direction on future model scenarios.

Specifically, DPUD staff recommended moving the start year for the Future Capacity Method from the year 2050 to 2040 based on knowledge about when the development reflected in the Place Type layer would likely begin. Results were also presented to the Texas Water Development Board (TWDB) in June 2023 and will be incorporated into the 2026 Regional Water Plan for Region C as part of their current statewide planning process. Results of the Baseline Forecast are shown in Section 4.

3.4 GIS-based Forecast Spatial Allocation into DWU Pressure Zones

After the population estimates were generated for the full DWU service area, a series of post-processing steps were used to allocate and summarize forecast data by DWU Pressure Zones. Boundary data was first combined using GIS to generate a combination layer containing Census Block Groups, NCTCOG Land Use, Dallas Base Zoning, ForwardDallas Place Types, and DWU Pressure Zones. An R script (a statistical programming package)[10] was used to allocate the population forecast data based on the underlying data associated with these combination polygons. Specifically, population was randomly assigned unit-by-unit to residential areas with existing capacity based on the DU/Acre and parcel type, until capacity was reached, or all population had been allocated. Results for this allocation are shown in 10-year increments for 2030, 2040 etc. through year 2080 in *Appendix B: Population Forecast by DWU Pressure Zone.* The starting population in 2021 is also provided by Pressure Zone.

[10] "What is R?." The Comprehensive R Archive Network, The R Foundation, 2023, r-project.org/about.html

4 FORECAST SCENARIOS

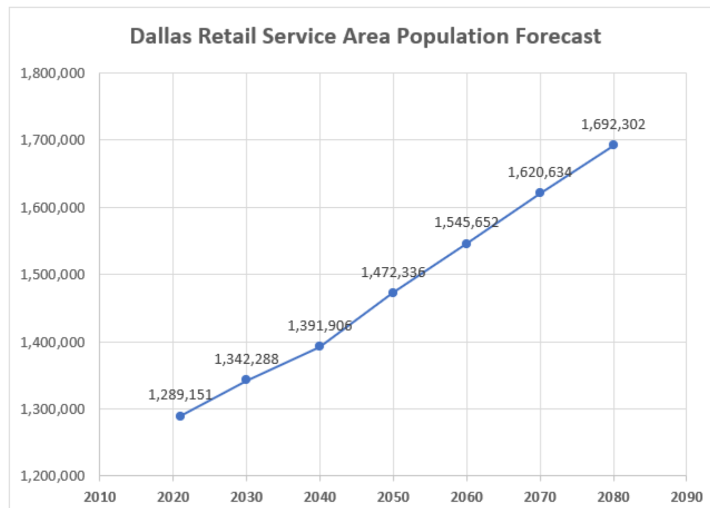
This section presents four of the many forecast scenarios explored during this analysis. The baseline scenario, alongside the three additional scenarios were developed in coordination with DWU and HDR, including feedback received during the Population Forecast Workshop on June 8th, 2023. Results from the baseline scenario are anticipated to be the primary input to the water demand forecast and related analysis, but the project team will consider additional scenarios during the water demand modeling process based on preliminary results and feedback.

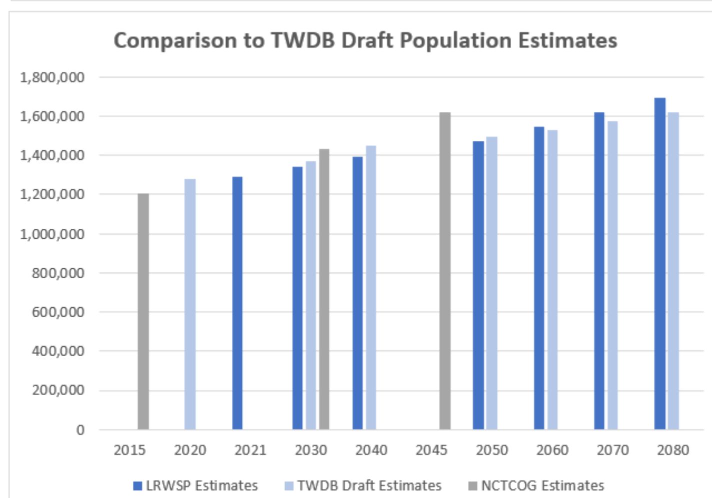
4.1 Baseline Forecast Settings

Refined model parameters and results are shown in Figure 8 below. The baseline forecast settings reflect a continuation of trends based on the most recent available data as detailed in the bulleted list below. Estimates were in-line with those recently produced by TWDB, with slightly lower estimates through 2050 and slightly higher estimates from 2060-2080. Results were reviewed by staff from MWM, HDR, DWU, and DPUD and were also recently reviewed and accepted by TWDB in June 2023.

Settings		
Name	**Value**	
Population Pressure Scenario	10-Year Trend	
Population Pressure (Annualized Growth)	0.48%	
Population Change Variability (Annualized "Noise")	7,313	
	Persons-per-Household	
Single-Family PPH	2.93	
Multi-Family PPH	2.05	
	Population Mix	
Single-Family	56.19%	
Multi-Family	40.94%	
Group Quarters	1.23%	
Mobile Home	1.63%	
Van, Boat, RV, etc.	0.02%	
Total	100.00%	
Difference	0.00%	
	New Build Settings	
Single-Family	2,467	
Multi-Family	4,724	
	Capacity Settings	
	Percentage	**Start Year**
Existing Vacant Units Annual Share	74.5%	
Current Zoning (New Builds) Annual Share	4.1%	
Future PlaceType (New Builds) Annual Share	4.1%	2040
SF Capacity Shortfall?		
MF Capacity Shortfall?		

Population Table			
Year	**LRWSP Estimates**	**TWDB Draft Estimates**	**NCTCOG Estimates**
2015	N/A	N/A	1,208,000
2020	N/A	1,277,664	N/A
2021	1,289,151	N/A	N/A
2030	1,342,288	1,372,734	1,430,500
2040	1,391,906	1,447,053	N/A
2045	N/A	N/A	1,619,100
2050	1,472,336	1,494,277	N/A
2060	1,545,652	1,529,969	N/A
2070	1,620,634	1,573,879	N/A
2080	1,692,302	1,622,202	N/A





Source: DWU_LRWSP_Draft Projection Tool Baseline Scenario_20230711_Submitted.xlsx, Modeled 2023-07-11

Figure 8. Baseline forecast model parameter settings and results (as of 2023-07-11)

The baseline model parameter settings are as follows:

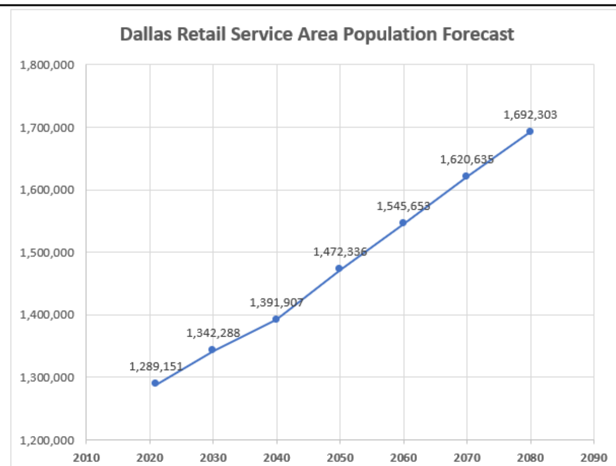
- Population Pressure (Annual Growth Rate) of 0.48%, as calculated from population growth rates from 2012-2022 Texas Demographic Center data.
- Population Change Variability of ±7,313, as calculated based on population growth variability from 2010-2021 ACS data.
- Persons-per-Household (PPH) for each housing category from 5-year ACS (2017-2021) tables B25032 (Tenure by Units in Structure) and B25033 (Total Population in Occupied Housing Units by Tenure by Units in Structure).
- Population Profile from 5-year ACS (2017-2021) table B25033.
- New Build Settings generated based on a 10-year average of historic building permit data obtained from Texas A&M University's Real Estate Research Center, split into Single-family and Multi-family and reduced based on the estimated percentage of issued permits that were constructed (98% for Single-family and 82% for Multi-family).
- Capacity Settings as described in step four of the previous Section 3.2.

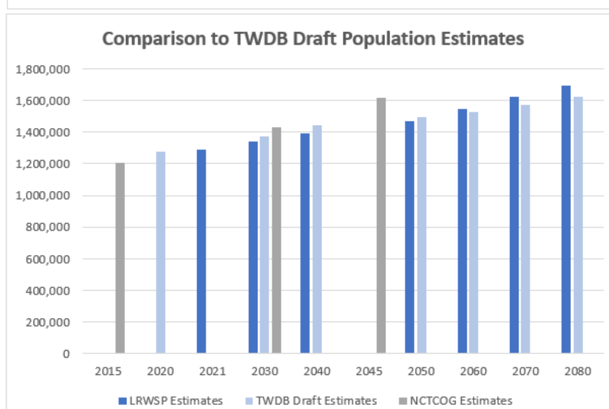
4.2 Multi-family Dominant Scenario

This scenario simulates a gradual switch of Single-family population to Multi-family throughout the course of the forecast. Specifically, ~18% of future Single-family population was moved to Multi-family, which had a starting percentage of 40.9% in 2021 and an ending value of 58.8% in 2080. The ending value (58.8%) was chosen by analyzing the population mix for the 20 most populous U.S. cities and selecting a city that represented a higher Multi-family percentage and reasonably similar total population (Chicago, IL). All other parameter settings match the Baseline scenario. Scenario parameters and results are shown in Figure 9 below.

Settings		
Name	**Value**	
Population Pressure Scenario	10-Year Trend	
Population Pressure (Annualized Growth)	0.48%	
Population Change Variability (Annualized "Noise")	7,313	
	Persons-per-Household	
Single-Family PPH	2.93	
Multi-Family PPH	2.05	
	Population Mix	
	Start	**End**
Single-Family	56.19%	38.35%
Multi-Family	40.94%	58.77%
Group Quarters	1.23%	1.23%
Mobile Home	1.63%	1.63%
Van, Boat, RV, etc.	0.02%	0.02%
Total	100.00%	100.00%
Difference	0.00%	0.00%
	New Build Settings	
Single-Family	2,467	
Multi-Family	4,724	
	Capacity Settings	
	Percentage	**Start Year**
Existing Vacant Units Annual Share	74.5%	
Current Zoning (New Builds) Annual Share	4.1%	
Future PlaceType (New Builds) Annual Share	4.1%	2040
SF Capacity Shortfall?		
MF Capacity Shortfall?		

Population Table			
Year	**LRWSP Estimates**	**TWDB Draft Estimates**	**NCTCOG Estimates**
2015	N/A	N/A	1,208,000
2020	N/A	1,277,664	N/A
2021	1,289,151	N/A	N/A
2030	1,342,288	1,372,734	1,430,500
2040	1,391,907	1,447,053	N/A
2045	N/A	N/A	1,619,100
2050	1,472,336	1,494,277	N/A
2060	1,545,653	1,529,969	N/A
2070	1,620,635	1,573,879	N/A
2080	1,692,303	1,622,202	N/A





Source: DWU_LRWSP_Draft Projection Tool MultiFamily Dominant Scenario_20230711_Submitted.xlsx, Modeled 2023-07-11

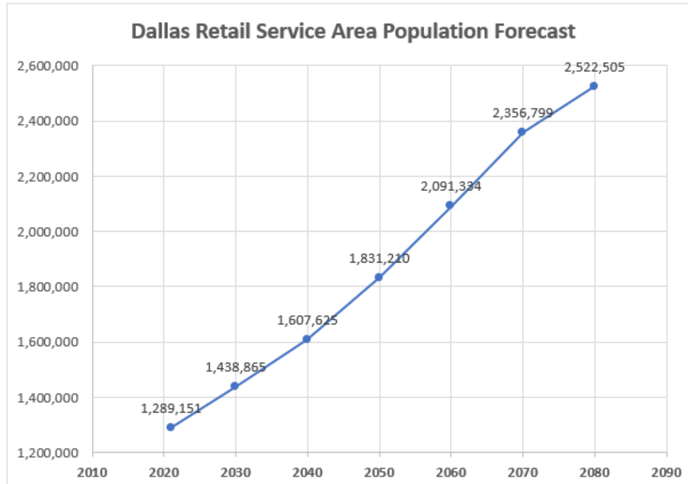
Figure 9. Multi-family Dominant forecast model parameter settings and results (as of 2023-07-11)

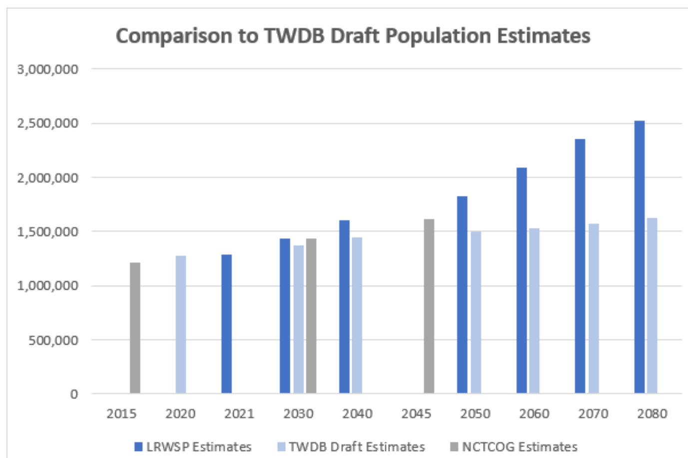
4.3 High Population Pressure Scenario

This scenario simulates a higher growth rate of 1.5% as observed during the 2012-2019 Pre-Covid period. All other parameter settings match the Baseline scenario. Scenario parameters and results are shown in Figure 10 below. Note that this is the only scenario that experienced a shortfall in housing capacity, with Single-family housing reaching capacity in 2038.

Settings		
Name	Value	
Population Pressure Scenario	Pre-Covid Trend	
Population Pressure (Annualized Growth)	1.50%	
Population Change Variability (Annualized "Noise")	7,313	
	Persons-per-Household	
Single-Family PPH	2.93	
Multi-Family PPH	2.05	
	Population Mix	
Single-Family	56.19%	
Multi-Family	40.94%	
Group Quarters	1.23%	
Mobile Home	1.63%	
Van, Boat, RV, etc.	0.02%	
Total	100.00%	
Difference	0.00%	
	New Build Settings	
Single-Family	2,467	
Multi-Family	4,724	
	Capacity Settings	
	Percentage	Start Year
Existing Vacant Units Annual Share	74.5%	
Current Zoning (New Builds) Annual Share	4.1%	
Future PlaceType (New Builds) Annual Share	4.1%	2040
SF Capacity Shortfall?	2038	
MF Capacity Shortfall?		

Population Table			
Year	LRWSP Estimates	TWDB Draft Estimates	NCTCOG Estimates
2015	N/A	N/A	1,208,000
2020	N/A	1,277,664	N/A
2021	1,289,151	N/A	N/A
2030	1,438,865	1,372,734	1,430,500
2040	1,607,625	1,447,053	N/A
2045	N/A	N/A	1,619,100
2050	1,831,210	1,494,277	N/A
2060	2,091,334	1,529,969	N/A
2070	2,356,799	1,573,879	N/A
2080	2,522,505	1,622,202	N/A





Source: DWU_LRWSP_Draft Projection Tool High Growth Rate Scenario_20230711_Submitted.xlsx, Modeled 2023-07-11

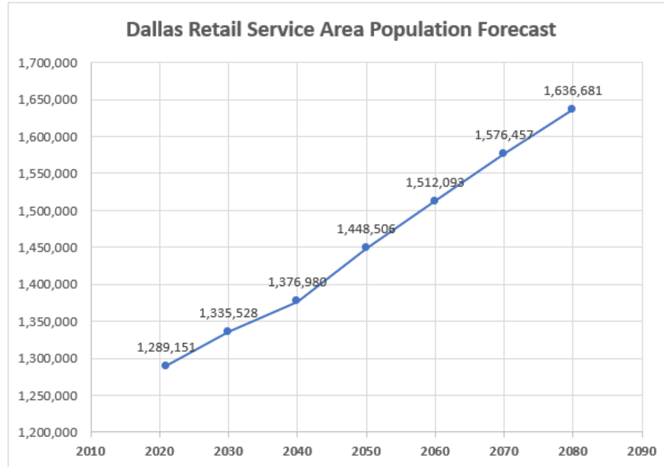
Figure 10. High Population Pressure forecast model parameter settings and results (as of 2023-07-11)

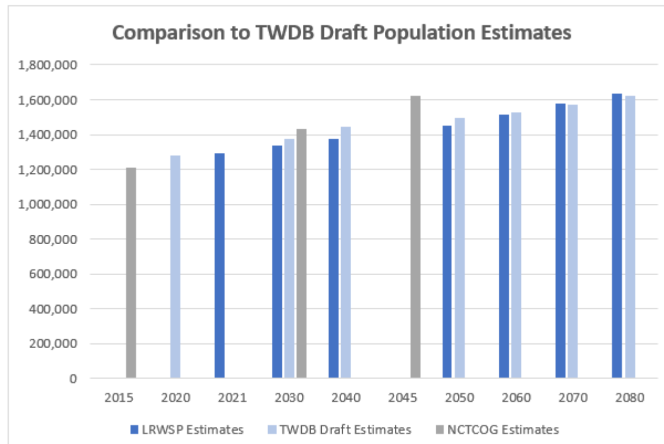
4.4 Texas Water Development Board Population Pressure Scenario

This scenario simulates a growth rate designed to match the rate used by TWDB in their draft projections released in May 2023, which was calculated as 0.41% based on analysis of estimates for the 2026 Regional Water Plan. All other parameter settings match the Baseline scenario. Scenario parameters and results are shown in Figure 11 below.

Settings		
Name	Value	
Population Pressure Scenario	TWDB Trend	
Population Pressure (Annualized Growth)	0.41%	
Population Change Variability (Annualized "Noise")	7,313	
	Persons-per-Household	
Single-Family PPH	2.93	
Multi-Family PPH	2.05	
	Population Mix	
Single-Family	56.19%	
Multi-Family	40.94%	
Group Quarters	1.23%	
Mobile Home	1.63%	
Van, Boat, RV, etc.	0.02%	
Total	100.00%	
Difference	0.00%	
	New Build Settings	
Single-Family	2,467	
Multi-Family	4,724	
	Capacity Settings	
	Percentage	**Start Year**
Existing Vacant Units Annual Share	74.5%	
Current Zoning (New Builds) Annual Share	4.1%	
Future PlaceType (New Builds) Annual Share	4.1%	2040
SF Capacity Shortfall?		
MF Capacity Shortfall?		

Population Table			
Year	LRWSP Estimates	TWDB Draft Estimates	NCTCOG Estimates
2015	N/A	N/A	1,208,000
2020	N/A	1,277,664	N/A
2021	1,289,151	N/A	N/A
2030	1,335,528	1,372,734	1,430,500
2040	1,376,980	1,447,053	N/A
2045	N/A	N/A	1,619,100
2050	1,448,506	1,494,277	N/A
2060	1,512,093	1,529,969	N/A
2070	1,576,457	1,573,879	N/A
2080	1,636,681	1,622,202	N/A





Source: DWU_LRWSP_Draft Projection Tool TWDB Growth Rate Scenario_20230711_Submitted.xlsx, Modeled 2023-07-11

Figure 11. TWDB Growth Rate forecast model parameter settings and results (as of 2023-07-11)

5 SUMMARY AND NEXT STEPS

This section presents a comparison of results from the four population forecast scenarios, discusses the next steps in the LRWSP that incorporate data from the population forecast, and describes resources available to aid in future Forecast updates.

5.1 Comparison of Scenario Results

A comparison of model results for total population from the four scenarios is shown in Table 3. Note that although the population totals from the Baseline scenario are nearly identical to those of the Multi-family Dominant scenario, the Single-family vs. Multi-family ratio and thus density of development differs substantially, with 31,160 additional Multi-family population and 31,160 fewer Single-family population projected for the Multi-family Dominant scenario by 2080.

Total Population				
Year	**Baseline**	**High Growth**	**MF-Dominant**	**TWDB**
2030	**1,342,300**	1,438,865	1,342,288	1,335,528
2040	**1,391,900**	1,607,625	1,391,907	1,376,980
2050	**1,472,300**	1,831,210	1,472,336	1,448,506
2060	**1,545,700**	2,091,334	1,545,653	1,512,093
2070	**1,620,600**	2,356,799	1,620,635	1,576,457
2080	**1,692,300**	2,522,505	1,692,303	1,636,681

Table 3. Population Estimates from each Scenario, 2030-2080

As mentioned previously, results from the baseline scenario are anticipated to be the primary input to the water demand forecast and related analysis, however the project team will consider additional scenarios as the modeling process progresses as needed based on preliminary results and feedback on the demand forecast results. For example, if the projected water demand totals for Single-family sector seem unreasonable, MWM could instead use the Multi-family Dominant scenario.

5.2 Future Population Forecast Updates

More information about tool usage, functionality, data update procedures, and scenario-based modeling is available in the training videos provided by MWM alongside the Excel-based Forecast model tools. Future updates to the existing scenarios and generation of additional scenarios can be achieved by following the steps outlined in these videos. For ease of reference, Table 4 is provided below showing the anticipated data update schedule for the primary Forecast data inputs that are generated by entities other than DWU and the City of Dallas.

Data Update Schedule		
Dataset	**Update Schedule**	**Anticipated Next Update**
Texas Demographic Center Population Data	6-months	February 2024
ACS Housing Data	Annually	December 2023
NCTCOG Land Use Data	5 Years	Fall 2027
Texas A&M Building Permit Data	Monthly (Annual data used in Forecast)	January 2024

Table 4. Anticipated Data Update Schedule for Regional, State, and Federal Datasets

5.3 LRWSP Next Steps

The population forecast estimates will feed directly into the LRWSP water demand projections to be completed using MWM's Demand Side Management Least Cost Planning Decision Support System Model (DSS Model). As of July 2023, these water demand modeling efforts are already underway.

Future potential project tasks may also include a GIS-based data analytics dashboard that presents both the population and water demand forecasts in a manner that allows real-time parameter changes and mapping of associated forecast results (similar to the real-time updates in the Excel-based tool but instead represented spatially). The GIS data processing outlined in this memo was undertaken with this task in mind, and the data is set up in a manner that would streamline the creation of a potential future dashboard.

APPENDIX A. SUPPORTING MAPS

This appendix presents maps of model inputs, including those modified during the model analysis workflow.

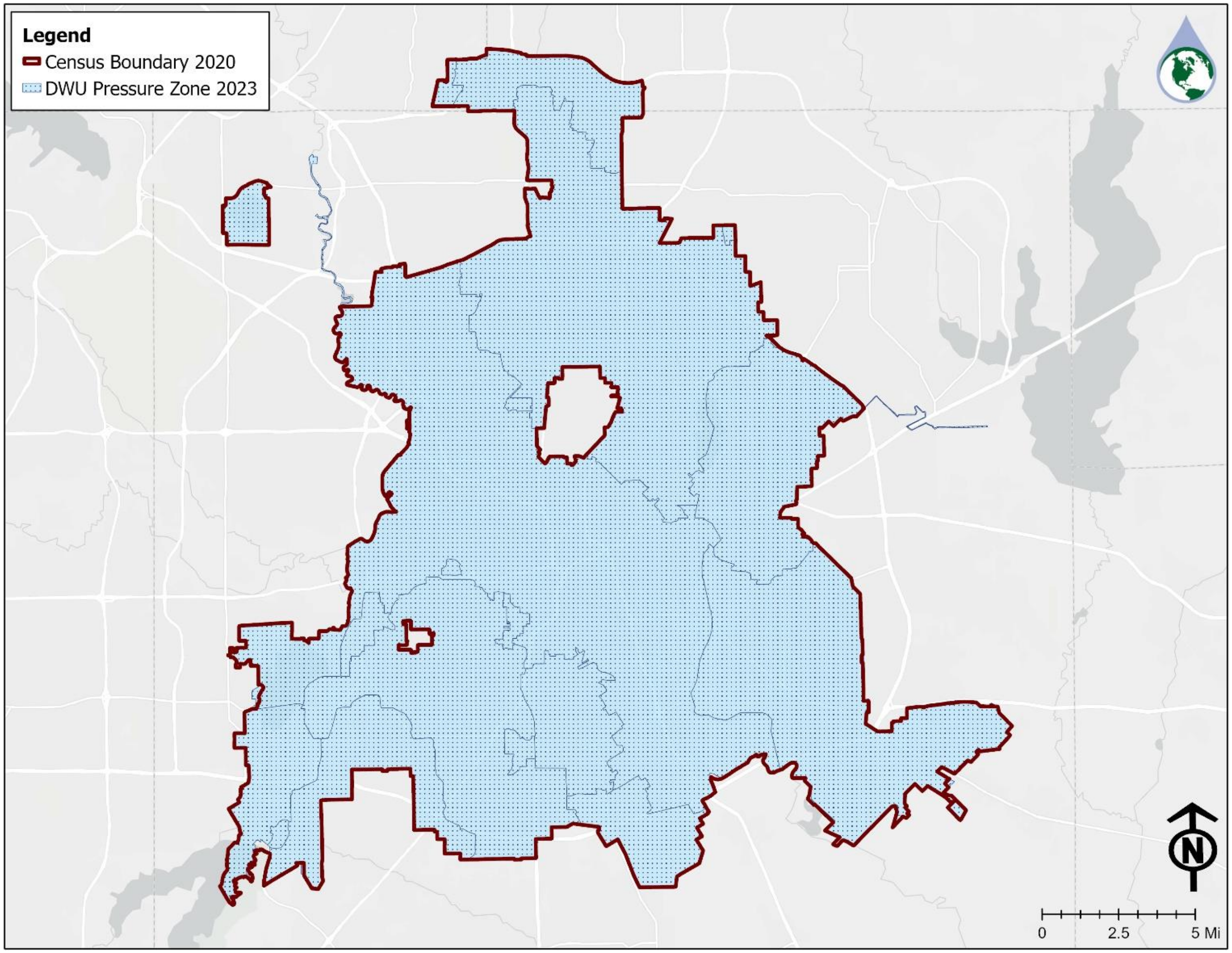


Figure A-1. Comparison of 2020 City of Dallas Census Boundary with 2023 DWU Pressure Zone Boundaries

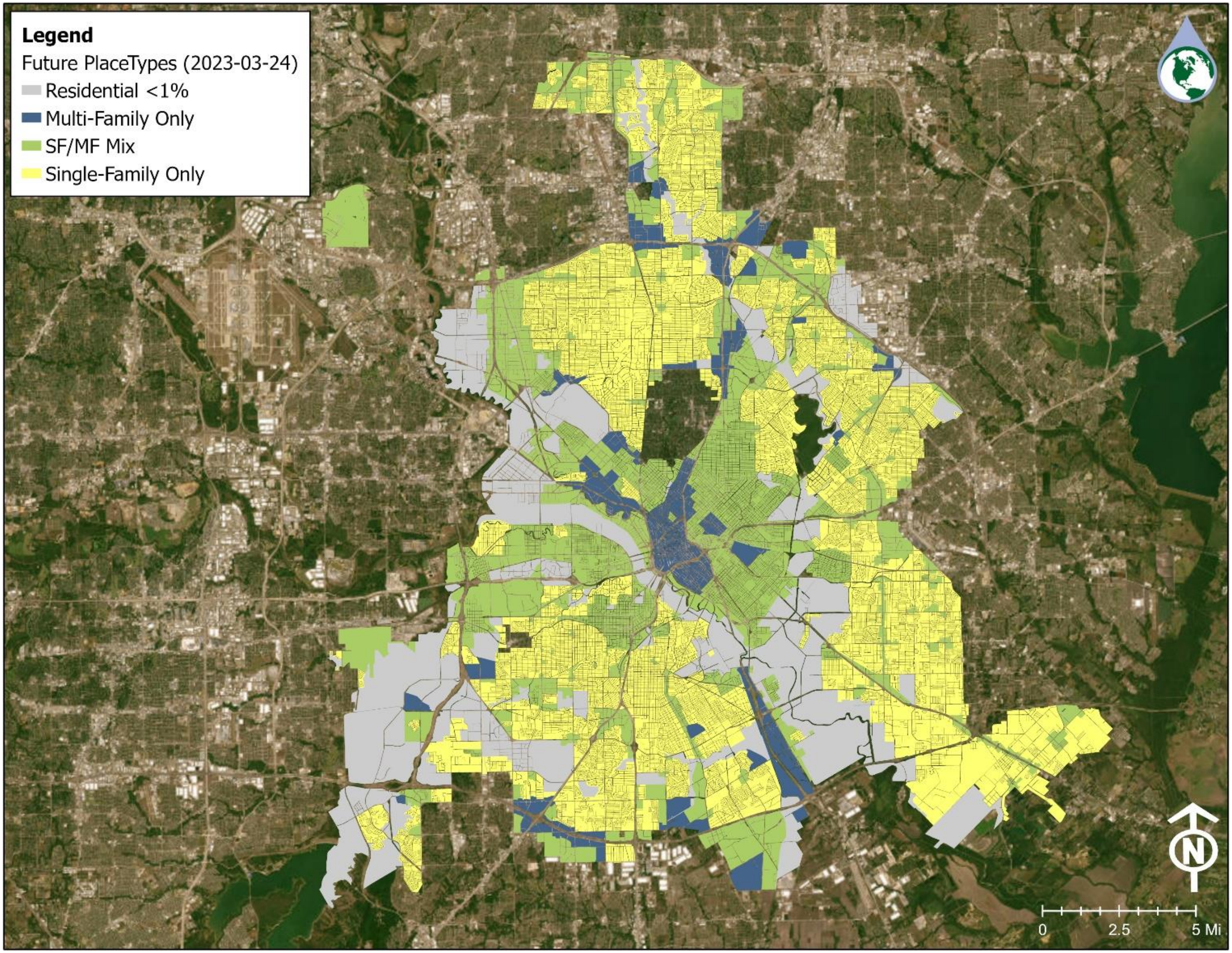


Figure A-2. Dallas Future Place Types with Residential land uses from 2023-03-24 data provided by Dallas Planning and Urban Design

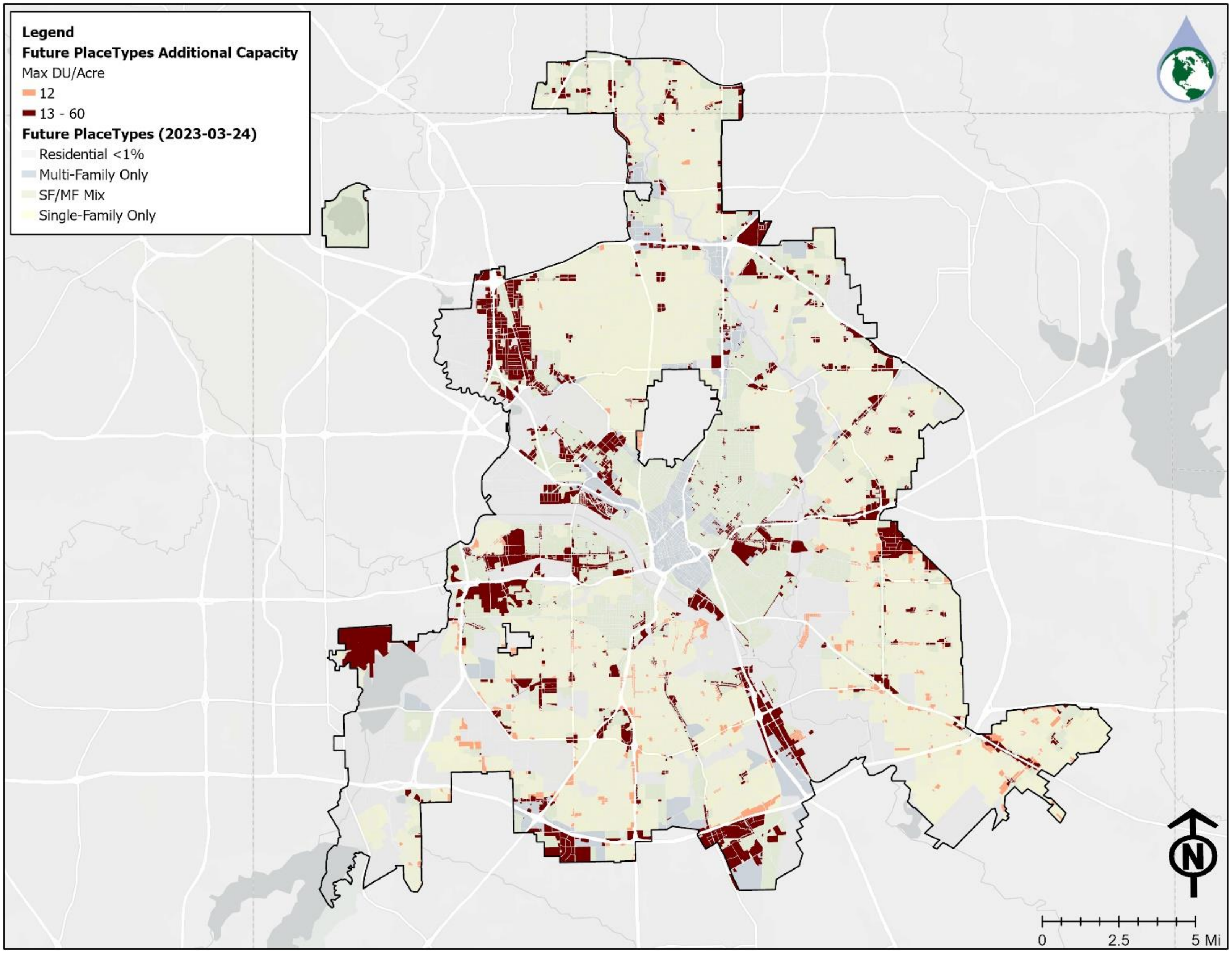


Figure A-3. Dallas Future Place Types with Residential land uses not currently zoned for Residential based on Dallas Base Zoning

APPENDIX B. POPULATION FORECAST BY PRESSURE ZONE

This appendix presents maps displaying current population (2021) and forecasted population for each decade (2030-2080) by Pressure Zone.

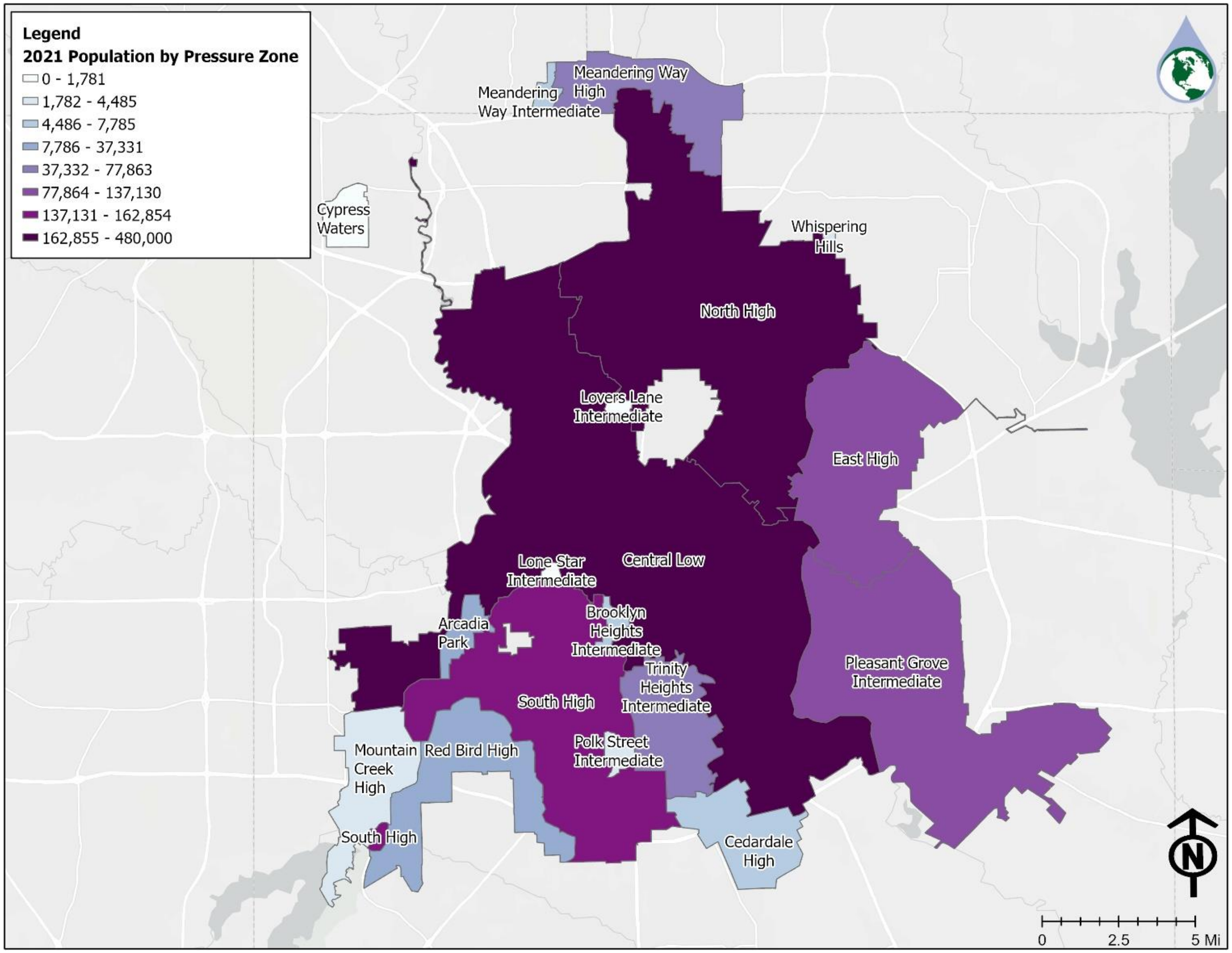


Figure B-1. 2021 Total Population by DWU Pressure Zone

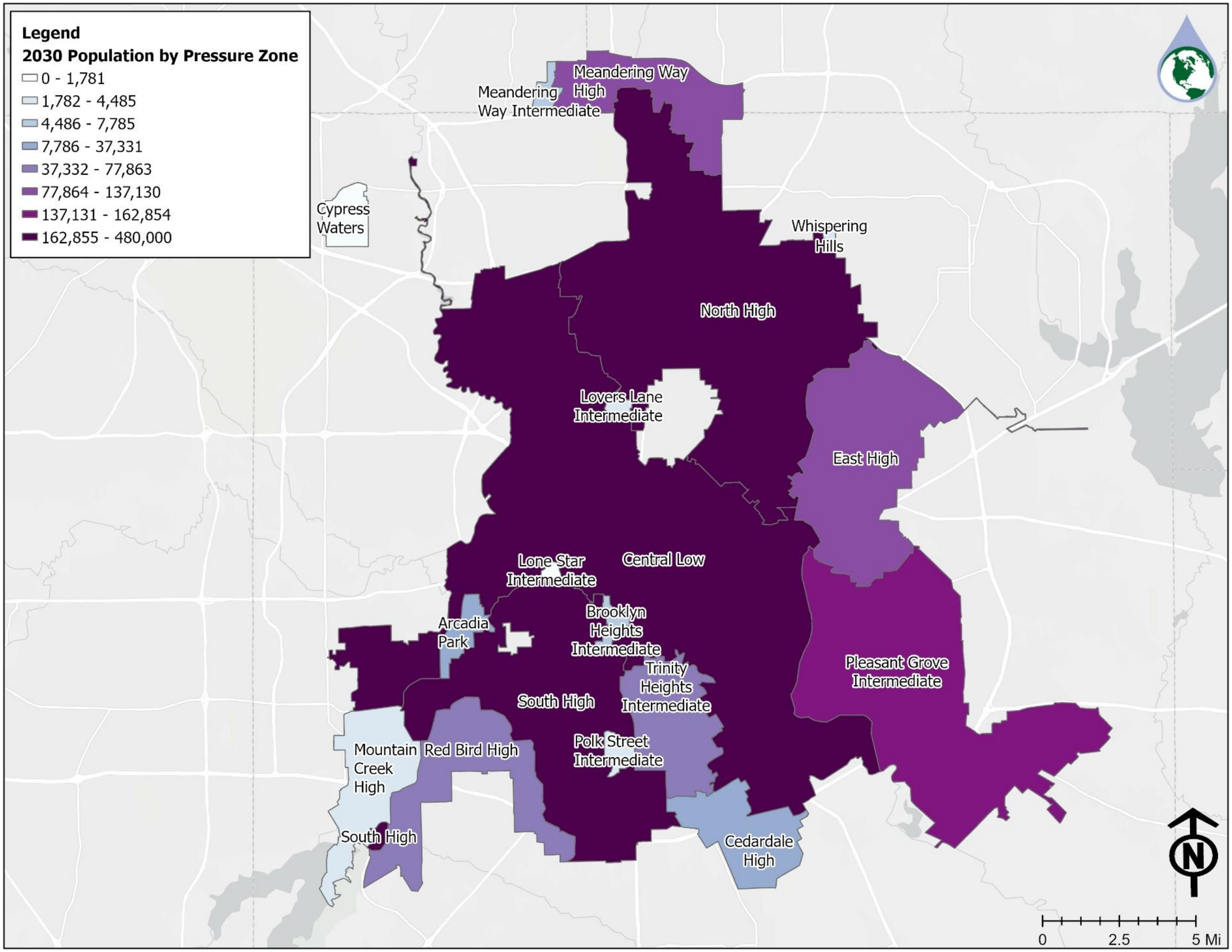


Figure B-2. 2030 Total Population by DWU Pressure Zone

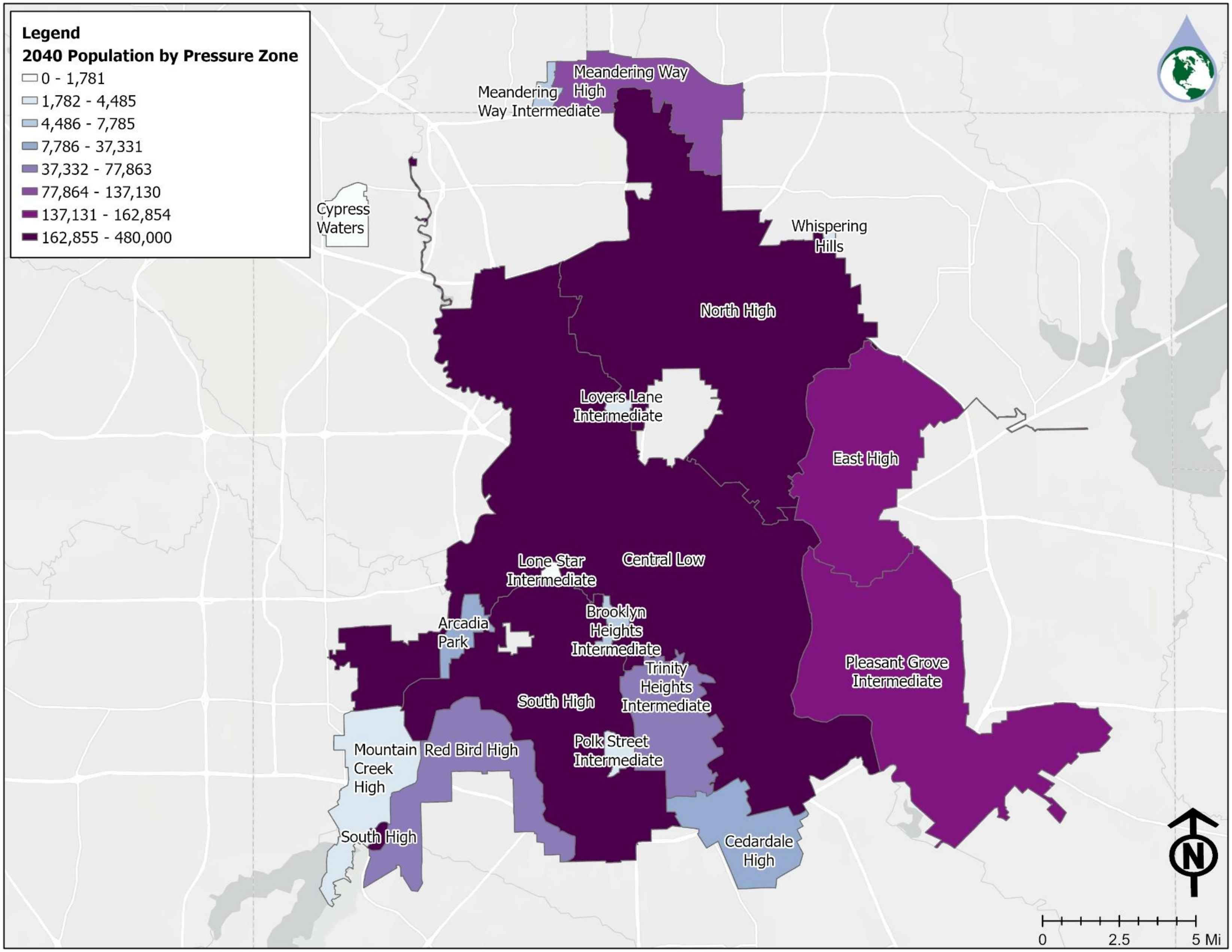


Figure B-3. 2040 Total Population by DWU Pressure Zone

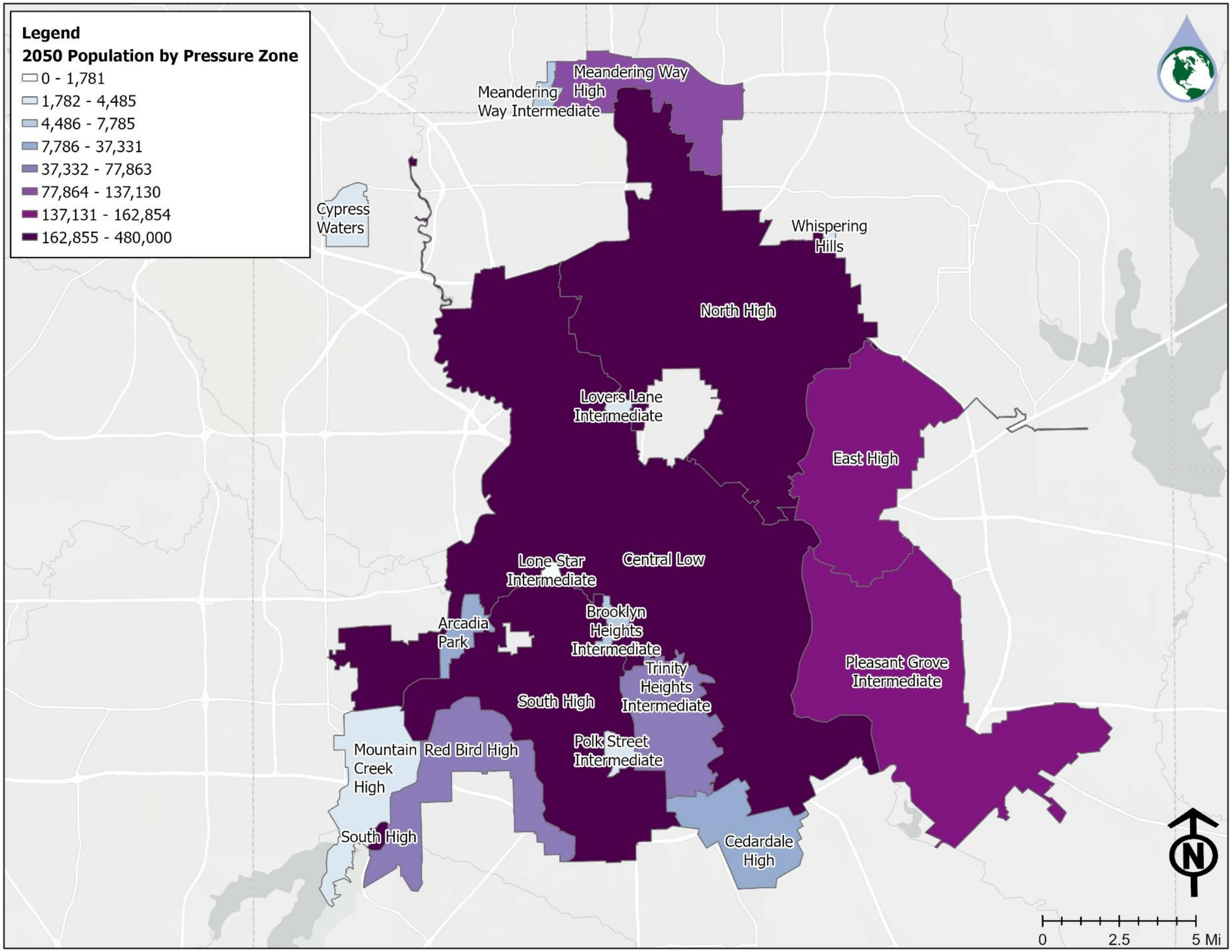


Figure B-4. 2050 Total Population by DWU Pressure Zone

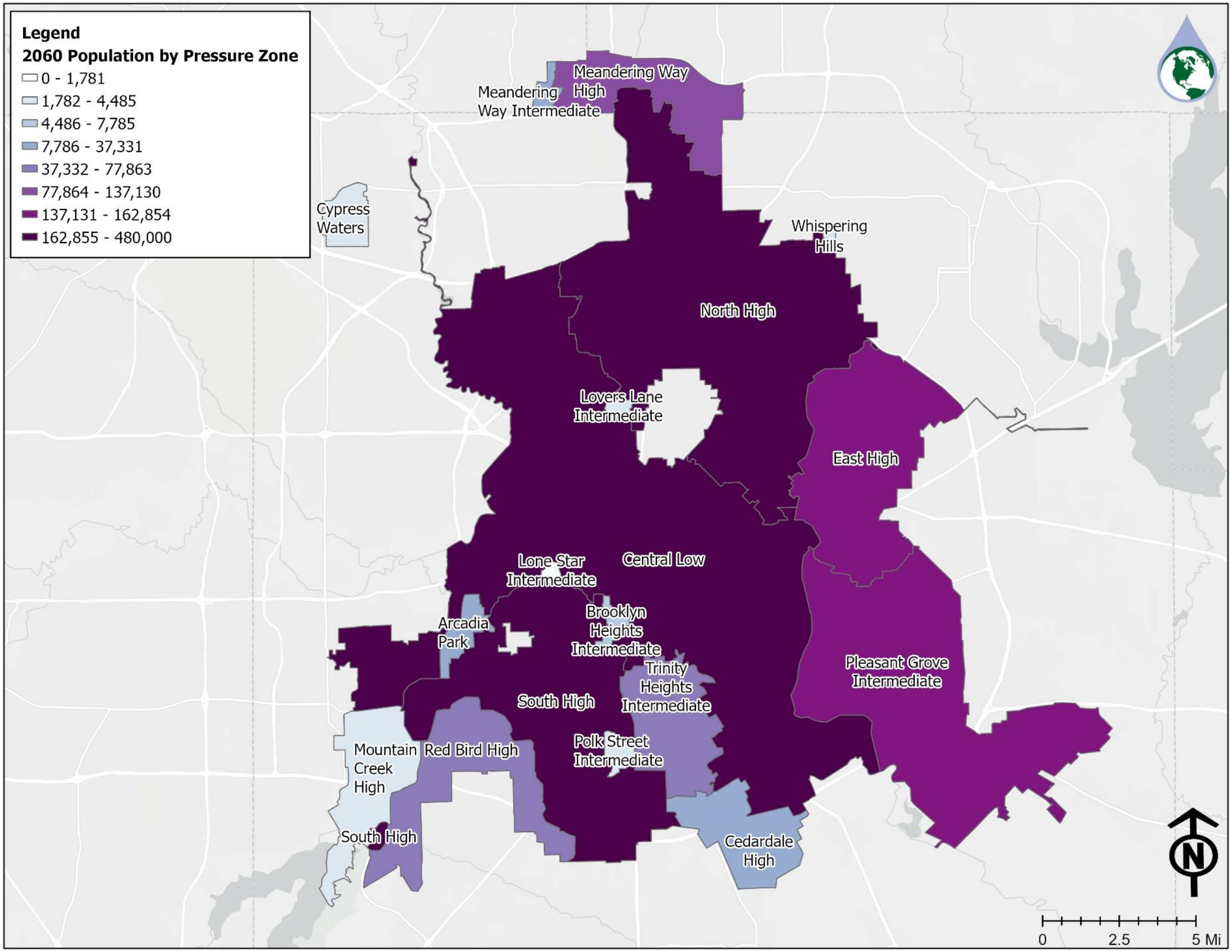


Figure B-5. 2060 Total Population by DWU Pressure Zone

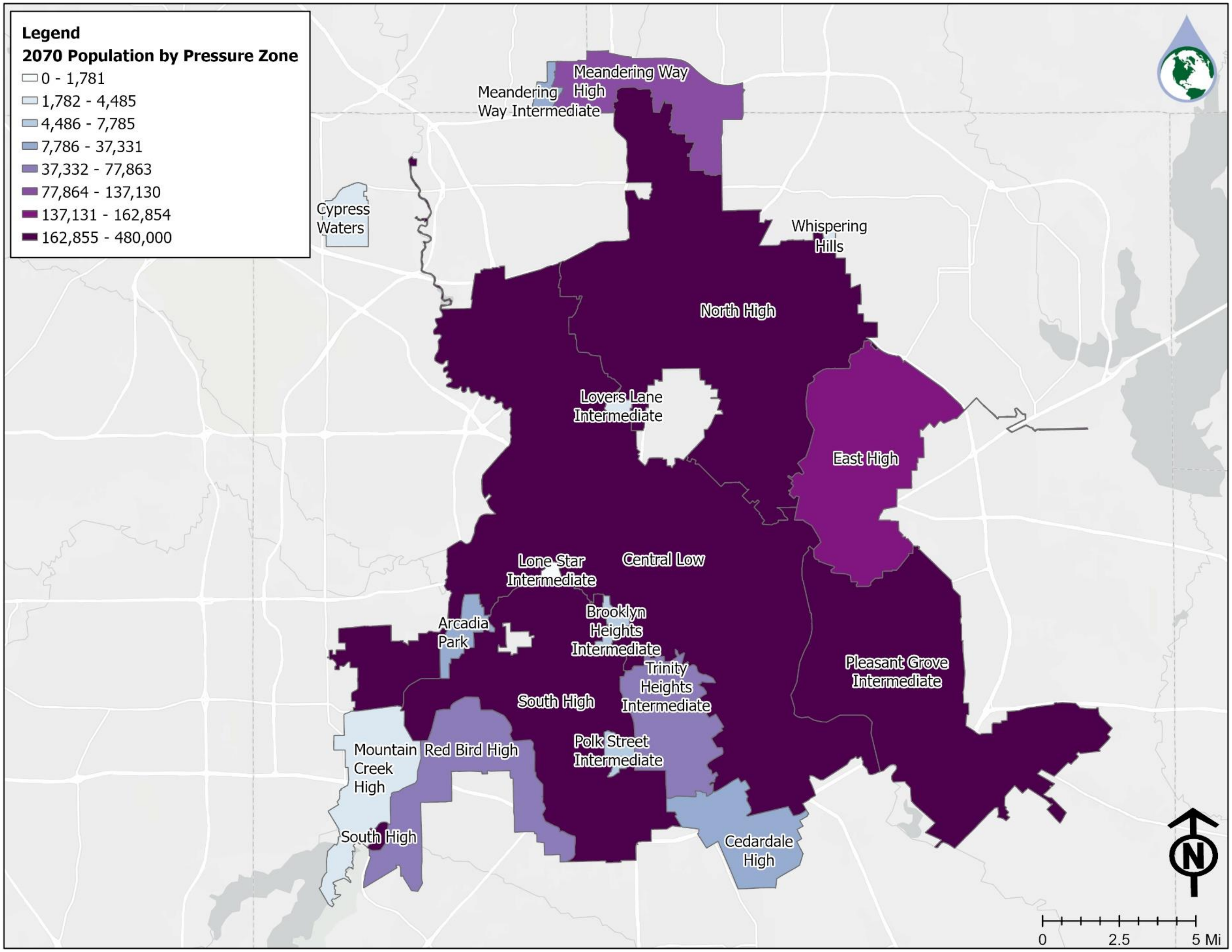


Figure B-6. 2070 Total Population by DWU Pressure Zone

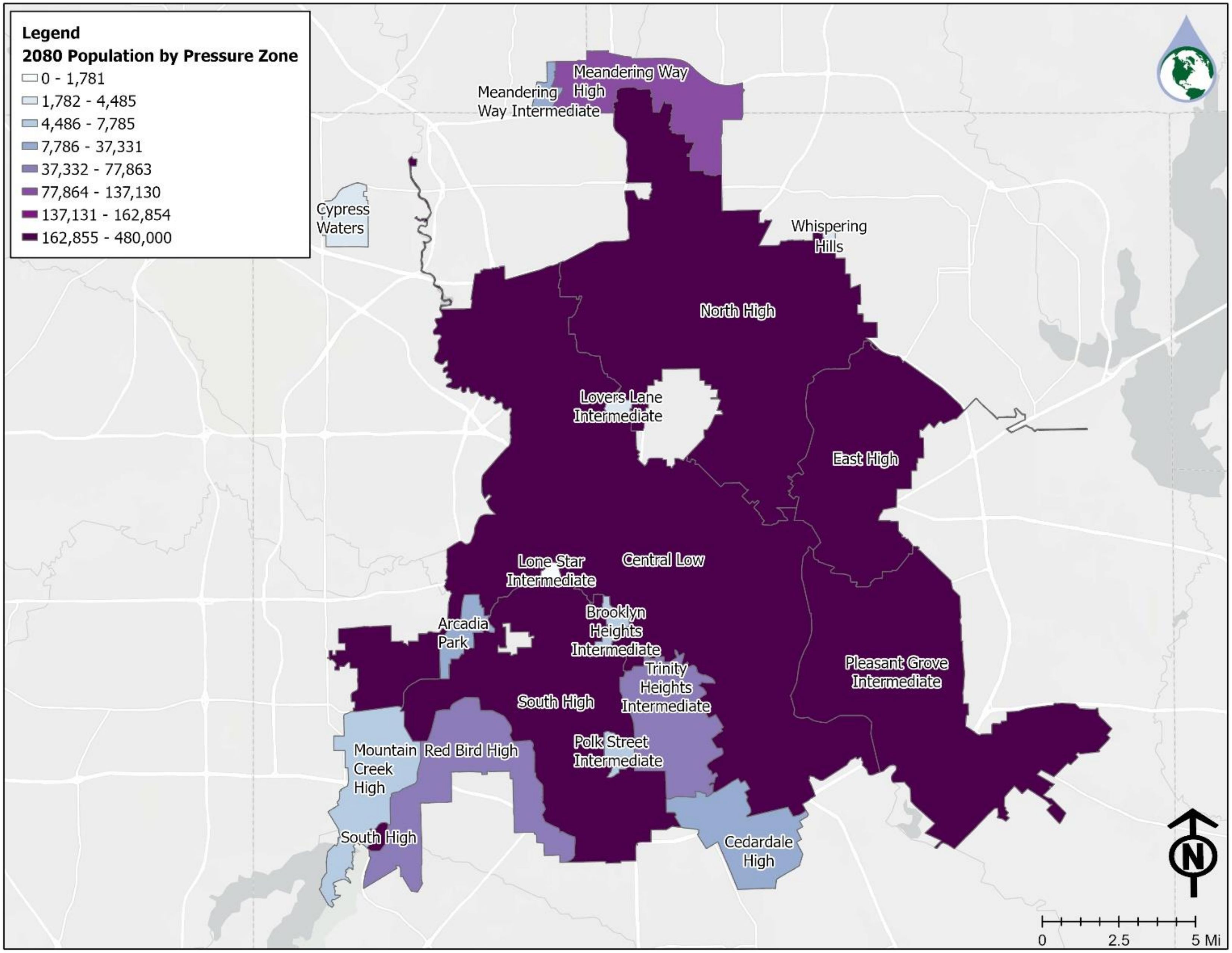


Figure B-7. 2080 Total Population by DWU Pressure Zone

Memo

Date: Tuesday, March 12, 2024

Project: DWU 2024 LRWSP

To: Denis Qualls, Chang Lee

From: Cory Shockley, Darren Thompson

Subject: 2024 LRWSP Supplemental Addendum to the Population and Water Demand Forecast TM

HDR is submitting the attached Dallas Water Utilities (DWU) 2024 Long Range Water Supply Plan Supplemental Addendum to the Population and Water Demand Forecasts (TM) dated March 6, 2024. In November 2023, the Texas Demographic Center released updated population estimates for January 1, 2023. DWU directed HDR to investigate the updated population pressures and trends resulting from this more recent population estimate. The newly released population estimate necessitated a revision to population and the projections. This Tech Memo steps through the revision process utilizing the most up to date information resulting in a new set of projections, this TM supersedes the results presented in the original population TM dated September 8, 2023.

Population – The population projection annualized growth rates were increased from 0.48% to 1.00% along with a higher 2023 starting population estimate of 1,309,879.

- Revised population projections increased over the planning period from 1,309,879 to 2,142,389 (64% growth over time) compared to 1,283,848 to 1,692,302 (32% growth over time) from the original analysis.
- Population projection in 2080 is 450,087 persons greater than the previous projection.

Demands - As a result of the increase in population, higher demands are anticipated compared to the original analysis. The demand scenarios were updated utilizing the revised population projections combined with Program B (inclusive of additional conservation measures) which results in an overall increase in demand projections.

- Revised demand projections in 2080 inclusive of the Program B conservation increased by 9% over the previous projections.
    - 512 mgd compared to the new projection of 559 mgd, increase of 47 mgd.
- These represent the average annual demands inclusive of the advanced conservation efforts.
- MWM includes the Program B conservation efforts as a demand reduction to the baseline demands. To be consistent with how advanced conservation was treated in previous planning efforts, HDR will be showing the potential savings realized from implementation of the Program B conservation as a supply strategy, not a demand reduction.
- Shifting additional conservation to a supply strategy from a demand reduction results in baseline demands for DWU of 452 MGD in 2030 and 620 MGD in 2080. However, these baseline

demands represent an average condition and do not account for higher demands experienced during drought periods. HDR will adjust these baseline demands to mitigate the risk of increased demands experienced during drought.

Population and demand projections by pressure zones have been updated and are incorporated into the TM.

HDR will now utilize the baseline demand (without Program B conservation programs) scenario developed by Maddaus Water Management (MWM) as the basis for developing demand scenarios that take into consideration weather variability and drought conditions. This will be the next step in providing DWU with a range of demands covering varying demand patterns providing DWU with the tools to appropriately plan for future supplies.

Technical Memorandum – ADMINISTRATIVE DRAFT

Date:	March 6, 2024
To:	Chang Lee, Dallas Water Utilities Denis Qualls, Dallas Water Utilities Cory Shockley, HDR Inc. Darren Thompson, HDR Inc.
From:	Zach Vernon, Maddaus Water Management Inc. Michelle Maddaus, Maddaus Water Management Inc. Tess Kretschmann, Maddaus Water Management Inc.
Title:	**DWU 2024 Long Range Water Supply Plan Supplemental Addendum to the Population and Water Demand Forecasts**

1 INTRODUCTION

Maddaus Water Management (MWM) is working with Dallas Water Utilities (DWU) and HDR Engineering, Inc. (HDR) to complete the population and water demand forecasts for DWU's 2024 Long Range Water Supply Plan (LRWSP). This technical memorandum presents the background, approach, and results used to update the 2030-2080 population forecast and water demand forecast estimates using updated population estimates from the Texas Demographic Center (TDC). This memo is an update of the previous Population Forecast Technical Memo dated September 8, 2023 and the upcoming Water Demand Forecast Technical Memo which presents results of the 2023 DSS Model, and includes updating the previous analysis with newly released data.

1.1 Background

In November 2023, the TDC released updated population estimates for January 1, 2023. DWU requested an update to the population and water demand forecasts using the January 1, 2023 population estimates. MWM, with DWU direction, also investigated updated population pressure parameters based on the recent trends observed by incorporating the most recently available TDC data.

2 POPULATION FORECAST UPDATE

The Population Forecast Model is used to estimate future population totals using a variety of input parameters, customized for DWU. The model uses various data sources as the basis for these estimates, including the TDC's population data and American Community Survey (ACS) housing mix data. The sections below describe the steps taken to update the model using recently available 2023 data, including comparison of results to the November 2023 modeling run.

2.1 Population Update Approach

The Population Forecast Model is implemented using a custom Excel-based tool with parameter settings, underlying data, and calculations visible in a model dashboard and supporting worksheets. MWM updated the population forecast by adding the January 1, 2023, population data from the TDC into the Excel-based tool. ACS data representing the 5-year 2018-2022 survey period (as released in December 2023) was also updated in the model supporting worksheets, which impacted the population forecast model parameters including available housing capacity. The updated model parameters resulting from the updated data are summarized in Table 1 below.

Variable	2023 Value	2024 Value	Change
Population Pressure (Annualized Growth)	0.48%	1.00%	+0.52%
Population Change Variability	7,313	7,081	-232
Persons-per-Household			
Single-Family Person per Household	2.93	2.91	-0.02
Multi-Family Person per Household	2.05	2.01	-0.04
Population Settings			
Starting Population	1,283,848	1,309,879	+26,031
Single-Family Population Proportion	56.19%	56.20%	+0.02%
Multi-Family Population Proportion	40.94%	40.83%	-0.11%
Group Quarters Population Proportion	1.23%	1.32%	+0.09%
Capacity Settings			
Single-Family Vacant Units	14,991	14,147	-844
Multi-Family Vacant Units	43,058	43,391	+333
Vacancy Rate	10.7%	10.4%	-0.3%
Existing Vacant Units Annual Proportion	74.5%	74.8%	+0.2%
Current Zoning (New Builds) Annual Proportion	4.1%	4.4%	+0.2%
Future Place Type (New Builds) Annual Proportion	4.1%	4.4%	+0.2%

Table 1. Population Model Parameters 2024 vs. 2023

Additional update efforts focused on the population pressure parameter used within the model. Within the model, the population pressure is applied as an annual growth rate to the previous year's population. The total population is allocated annually, based on available housing capacity data. The previous population pressure applied was 0.48% as observed in the 10-year trend from 2012-2022.

MWM worked with DWU to investigate two scenarios of this 11-year trend based on newly available 2023 data.

- Scenario 1: The first was a blend between the pre-pandemic (2012-2019) and 11-year trend (2012-2023). The goal of first scenario was to lessen the impacts of the population decline observed during the COVID pandemic years by including the pre-COVID pandemic trend.
- Scenario 2: The team also explored a second scenario representing the pandemic rebound trend using 18 months of data from July 2021 to January 2023. Table 2, on the next page, shows both scenarios and associated population rate increases that were investigated. A final value of 1.0% average annual population growth was selected based on rounding down the average of the "Scenario 1: Blended 7-year / 11-year" value (1.06%) and "Scenario 2: Recent 18 months (07/21 to 01/23)" value (1.07%). Draft results were presented to DWU staff and discussed during weekly check-in meetings, leading to final approval of the 1.0% annualized population growth rate.

Population Growth Rate (TX State Demographer Population Data)		
Time Period	**Total % Growth Rate during Time Period**	**Annualized Growth Rate**
10 Year (2012-2022)	4.9%	0.48%
7 Year (2012-2019)	11.0%	1.50%
11 Year (2012-2023)	7.0%	0.62%
Scenario 1: Blended 7-year/ 11-year rates	9.0%	**1.06%**
Scenario 2: Recent 1.5 Year rate (July '21 to Jan '23)	1.6%	**1.07%**
Selected Scenario: Rounded Average of 1 & 2	N/A	**1.0%**

Table 2. Population Scenario Options

2.2 Population Update Results

Housing capacity was based on the North Central Texas Council of Governments (NCTCOG)'s 2020 Land Use Inventory[1], Dallas Base Zoning (Zoning)[2], and the ForwardDallas Place Type (Place Type)[3] layer.

Results of the updated population model are shown in Figure 1 below, which compares the population estimates from the November modeling run to the population estimates from the updated January run. Note that the change in slope between 2020 and 2030 is related to 2020-2023 population loss observed during the COVID pandemic. Table 3, below, displays the results of the 2024 forecast, including percent change over time.

Population Over Time - 2024 Model Results			
Year	**Population**	**% Change**	**Annualized Change**
2010	1,304,379	N/A	N/A
2020	1,358,328	4.1%	0.41%
2023	1,309,879	-3.6%	-1.20%
2030	1,393,479	6.4%	0.89%
2040	1,508,053	8.2%	0.79%
2050	1,647,570	9.3%	0.89%
2060	1,804,405	9.5%	0.91%
2070	1,959,091	8.6%	0.83%
2080	2,142,389	9.4%	0.90%

Table 3. Updated (2024) Population Forecast Results

[1] "2020 Land Use." NCTCOG GIS Open Data, North Central Texas Council of Governments, 2023, data-nctcoggis.opendata.arcgis.com/datasets/NCTCOGGIS::2020-land-use/explore.

[2] "Zoning Districts." City of Dallas, 2023, dallascityhall.com/departments/sustainabledevelopment/planning/Pages/zoning-districts.aspx.

[3] "Place Types and Land Use." Dallas Planning and Urban Design, 2023, dallascityhall.com/departments/pnv/Forward-Dallas/Pages/Placetypes_LandUse.aspx.

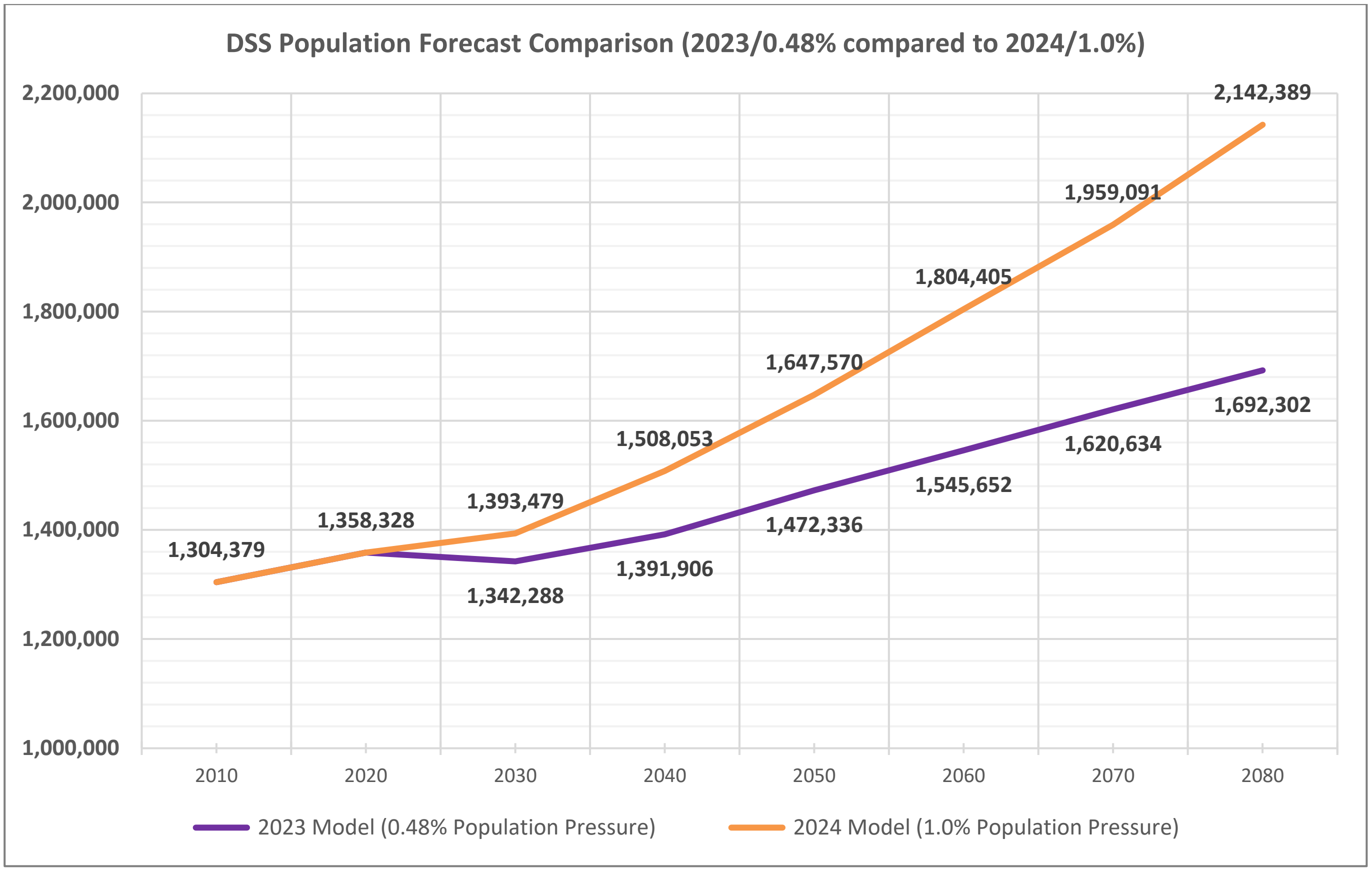


Figure 1. 2024 Population Estimates compared to 2023 Population Estimates

The parameter changes detailed in Section 2.1 all impacted the population estimates, but the primary drivers resulting in higher population estimates are:

1. Higher population growth rate: from 0.48% to 1.0%
2. Higher starting population in 2023: 2.03% higher than 2022 population
3. Lower housing vacancy rate in 2023: from 10.7% to 10.4%

The higher population growth rate had the largest impact of the three drivers above, as a higher annual growth rate directly produces higher population estimates. Similarly, the updated 2023 numbers demonstrate a continued pandemic rebound and result in higher overall population estimates, especially when coupled with the increased growth rate. Finally, the lower vacancy rate allows for a greater percentage of available housing to be filled leading to higher population estimates. All three drivers have a compounding impact over time.

MWM also updated the population estimates by DWU pressure zone using a GIS-based spatial allocation process, with population randomly assigned unit-by-unit to residential areas with existing capacity based on the Dwelling Units per Acre and parcel type, until capacity was reached, or all population had been allocated. Results for this allocation are shown in 10-year increments for 2030, 2040 etc. through year 2080 in *Appendix B: Population Forecast by DWU Pressure Zone.* The starting population in 2023 is also provided by Pressure Zone. Population estimates by Pressure Zone are shown in Table 4, on the following page.

		Population Estimates						
Pressure Zone	Acres	2023	2030	2040	2050	2060	2070	2080
Arcadia Park	1,304	8,274	8,751	9,323	9,945	10,512	11,037	11,683
Brooklyn Heights Intermediate	550	4,259	4,529	4,911	5,540	6,196	6,770	7,408
Cedardale High	5,549	7,143	7,483	7,924	8,444	9,105	9,723	10,472
Central Low	68,469	277,203	296,124	326,330	364,197	410,473	460,694	521,129
Cypress Waters	1,688	1,466	1,474	1,633	1,815	2,052	2,285	2,587
East High	16,321	117,835	125,417	134,926	145,830	156,965	167,199	179,256
Lone Star Intermediate	169	0	0	6	21	64	93	134
Lovers Lane Intermediate	239	1,634	1,851	2,091	2,356	2,635	2,883	3,238
Meandering Way High	7,148	71,446	76,747	83,958	92,200	101,880	114,492	130,042
Meandering Way Intermediate	509	6,004	6,378	7,064	7,591	8,176	8,723	9,346
Mountain Creek High	6,367	4,115	3,046	3,259	3,605	4,030	4,536	5,201
North High	42,661	301,102	322,559	352,418	388,325	427,943	462,987	503,957
Pleasant Grove Intermediate	29,016	125,829	133,194	141,647	152,247	164,149	175,232	188,323
Polk Street Intermediate	586	3,797	4,012	4,233	4,420	4,598	4,767	4,966
Red Bird High	9,158	34,255	36,066	38,694	42,031	45,756	48,758	52,258
South High	276	298,866	315,882	335,556	360,768	387,084	411,847	440,311
Trinity Heights Intermediate	6,758	44,619	47,800	51,754	55,746	60,156	64,317	69,199
Whispering Hills	144	2,032	2,167	2,326	2,490	2,631	2,750	2,879
Population Totals	196,910	1,309,879	1,393,479	1,508,053	1,647,570	1,804,405	1,959,091	2,142,389

Table 4. Population Estimates by DWU Pressure Zone

3 WATER DEMAND FORECAST UPDATE

3.1 Water Demand Update Approach

MWM updated the water demand forecast for the DWU retail service area using the updated population estimates described in Section 2. As with the draft water demand forecast, modeling work was performed using the Least Cost Planning Decision Support System (DSS Model). Within the DSS Model, MWM updated the Historical Population data to include 2023, adjusted the DSS Model Start Year to 2024, and produced updated water demands for 2030-2080. Job count estimates were also updated using the recently produced population data, as there is a direct relationship assumed between population and jobs in the DWU retail service area.

All other inputs (Wholesale Data, Production, Consumption, Non-Revenue Water, etc.) were held constant from the 2023 modeling work. The DSS Model was recalibrated after the water demand forecast inputs were updated, and all calibration checks passed checks for reasonable value ranges.

3.2 Water Demand Update Results

After DSS Model updates were completed, the water demand forecast was generated using the processes detailed in the upcoming Water Demand Forecast TM. Broadly, the DSS Model is an end-use model that breaks down total water production (water demand in the service area) to specific water end uses. It uses a bottom-up approach that allows for multiple criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes, and conservation efforts.

Demand data for the DWU retail service area was reconciled with available demographic data to characterize the water usage for each customer category in terms of number of users per account and per capita water use, and further analyzed to approximate the split of indoor and outdoor water usage in each customer category. The indoor/outdoor water usage was further divided into typical end uses for each customer category. The DSS

Model was then used to evaluate the impact of DWU-selected conservation measures (from Conservation Program B, as listed in Section 3.3 of this TM).

Future water demand projections for DWU Wholesale customer cities were taken directly from the Texas Water Development Board (TWDB) available Region C Water Planning Group projections and were included as a standalone customer category (Wholesale, abbreviated as WHO in the model). These TWDB projections were combined with the updated projections produced for the DWU retail service area to produce updated forecast totals as shown in Figure 2 below, which includes a comparison to the 2023 DSS Model estimates.

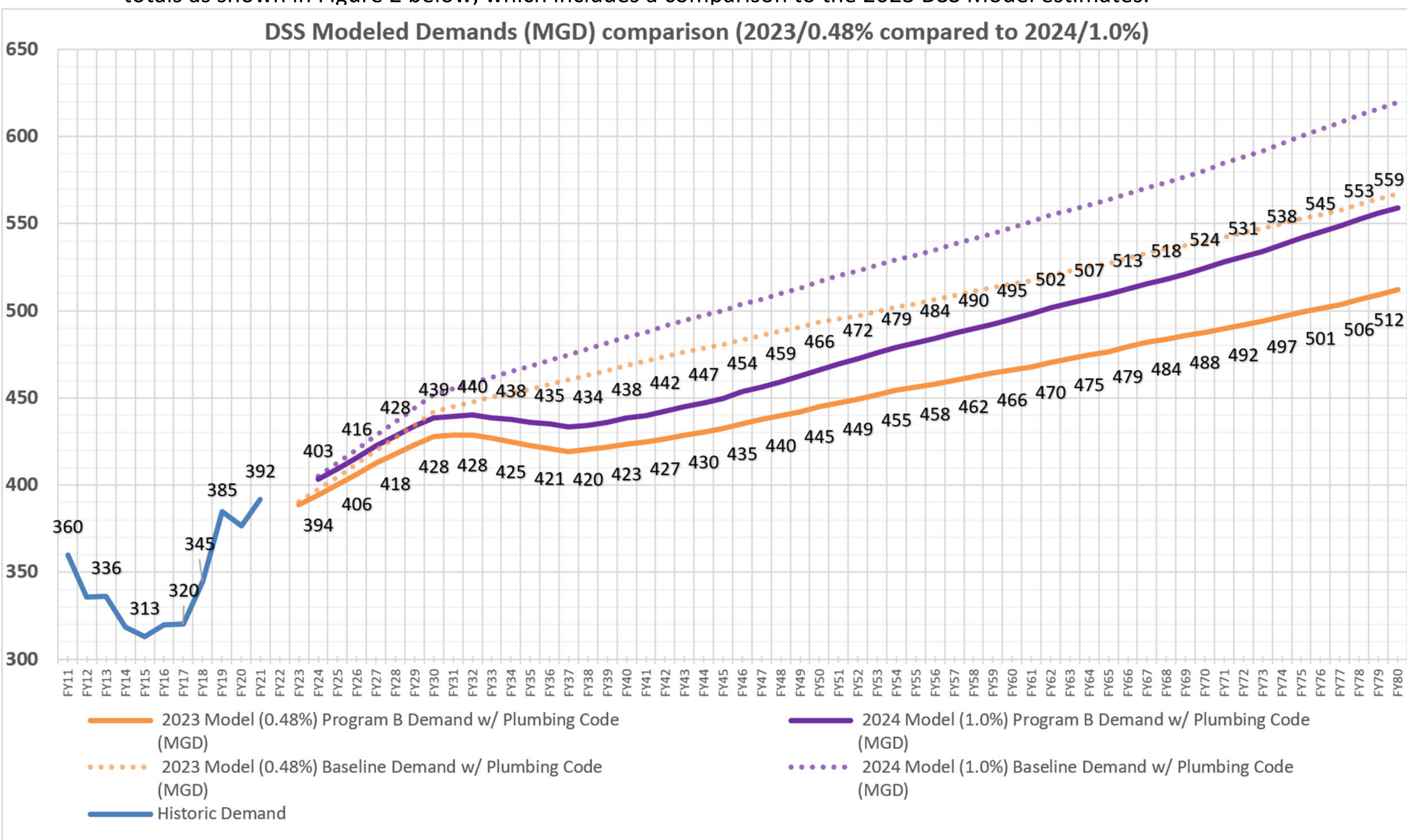


Figure 2. 2024 Water Demand Estimates compared to 2023 Water Demand Estimates

3.3 Water Conservation Program B

The selected Conservation Program B has a significant impact on the water demand forecasts, as the conservation savings offset increases to demand. There are some situations where the conservation savings outpace demand increases and lead to temporary reductions in overall demand, as observed during the early 2030s decrease in DWU demands. Conservation measures were reviewed and discussed in detail during the DWU Conservation Measure Workshop and subsequent meetings and were reviewed by DWU staff for accuracy for model settings such as start date and anticipated per-participant savings.

As Figure 3 below demonstrates, conservation savings jump from <20 Million Gallons per Day (MGD) to >40 MGD during a 5-year period from FY32 to FY36. Three measures are the drivers for this demand offset, each bolded in the list below and shown in shades of blue within the chart. Measure 1 (Water Loss), Measure 5 (Advanced Metering Infrastructure), and Measure 24 (Conservation Targets in Wholesale Contracts) each quickly increase water savings during the FY32 to FY36 time period, which accounts for the temporary stall and decrease in DWU demands.

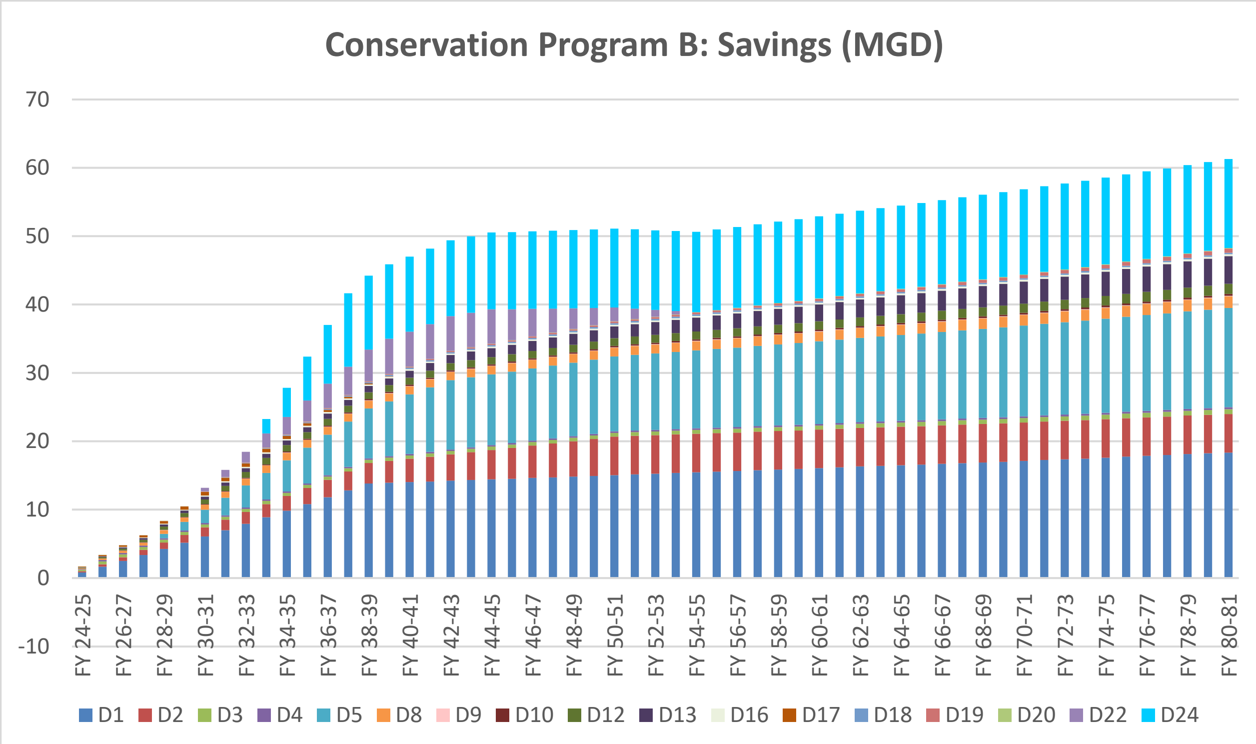


Figure 3. Final Population Model Parameters

D1 Water Loss: Bottom of Chart
D2 Conservation Tiered Rates
D3 Public Outreach & Education
D4 School Education
D5 Advanced Metering Infrastructure (AMI)
D8 Irrigation Systems Evaluations
D9 Residential Irrigation System Incentives
D10 ICI Incentives
D12 Enhanced Irrigation Enforcement Initiative
D13 Landscape Irrigation Ordinance
D16 Minor Plumbing Repair (MPR)
D17 Residential Toilet Vouchers & Rebates (New Throne for your Home)
D18 Residential and ICI Water Efficiency Surveys
D19 ICI Nonprofit Plumbing Retrofits
D20 City Facility Retrofits
D22 Fixture Retrofit on Resale Ordinance
D24 Water Conservation Policy in New/Existing Supply Contracts: Top of Chart

3.4 Water Demand Allocation by Pressure Zone

As with the population estimates, MWM also generated water demand estimates by DWU pressure zone. The water demand allocation was generated using three pressure zone-based ratios, listed below.

1) **Residential:** For base year and each projected decade, calculated Pressure Zone Population / Total DWU Population and applied this ratio to the total projected residential water demand to generate residential water demand by Pressure Zone.
2) **Non-Residential**: For 2021 (most recent available data year), used the Longitudinal Employer-Household Dynamics (LEHD) OnTheMap[4] web tool to generate Primary Jobs by Pressure Zone.

[4] "LEHD OnTheMap". U.S Census Bureau, 2024, https://onthemap.ces.census.gov/

Calculated ratio of Pressure Zone Primary Jobs / Total Primary Jobs and applied this ratio to the total projected non-residential demand to generate non-residential water demand by Pressure Zone.

3) **Non-Revenue Water (NRW):** Combined the two ratios described above and applied to NRW estimates for the base year and each projected decade. This assumes that NRW will be applied equally across customer types.

Maps of water demand by pressure zone were also produced and are provided in *Appendix B: Baseline Forecast with Plumbing Code* and *Appendix C: Conservation Program B with Plumbing Code.* Two related tables were also produced in *Appendix D: Combined Water Demand Forecast by Entity*, which include wholesale demands for DWU customer cities as estimated by the TWDB Region C Water Planning Group alongside demands by pressure zone. The wholesale demands from TWDB were allocated based on the portion of total water usage provided by DWU, as described in greater detail in the Water Demand Forecast TM. Table D-1 includes all current wholesale customers, while Table D-2 also includes potential future customers.

4 CONCLUSIONS

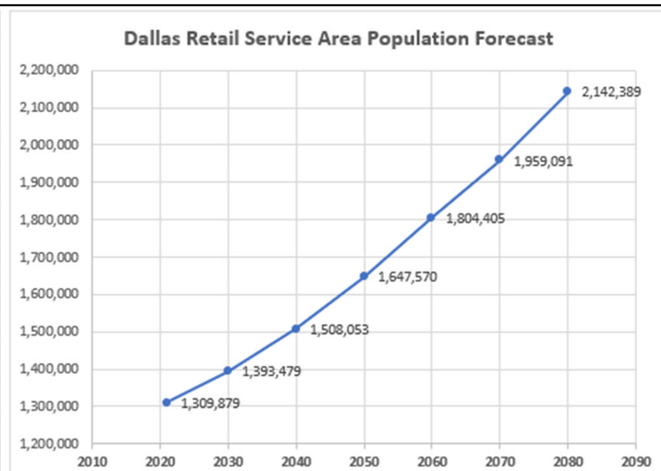
Updating the population model using the latest TDC data for January 2023 generated future population and water demand estimates that are less influenced by the population decline observed during the peak of the Covid 19 pandemic. As a result, the forecast outputs are more appropriate for DWU's long range water demand planning. The primary updates performed during this 2024 modeling update impacted the population forecast, and parameters and results from the final updated Population Model are shown in Figure 4 below.

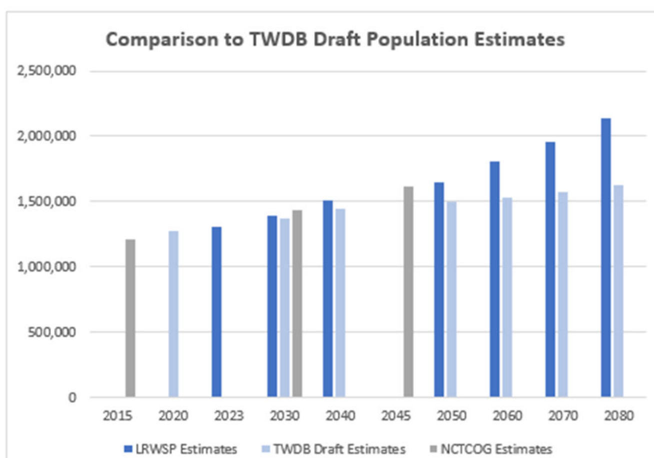
Settings

Name	Value	
Population Pressure Scenario	Blended 1.0% Trend	
Population Pressure (Annualized Growth)	1.00%	
Population Change Variability (Annualized "Noise")	7,081	
	Persons-per-Household	
Single-Family PPH	2.91	
Multi-Family PPH	2.01	
	Population Mix	
Single-Family	56.20%	
Multi-Family	40.83%	
Group Quarters	1.32%	
Mobile Home	1.63%	
Van, Boat, RV, etc.	0.02%	
Total	100.00%	
Difference	0.00%	
	New Build Settings	
Single-Family	2,568	
Multi-Family	4,839	
	Capacity Settings	
	Percentage	**Start Year**
Existing Vacant Units Annual Share	74.8%	
Current Zoning (New Builds) Annual Share	4.4%	
Future PlaceType (New Builds) Annual Share	4.4%	2040
SF Capacity Shortfall?		
MF Capacity Shortfall?		

Population Table

Year	LRWSP Estimates	TWDB Draft Estimates	NCTCOG Estimates
2015	N/A	N/A	1,208,000
2020	N/A	1,277,664	N/A
2023	1,309,879	N/A	N/A
2030	1,393,479	1,372,734	1,430,500
2040	1,508,053	1,447,053	N/A
2045	N/A	N/A	1,619,100
2050	1,647,570	1,494,277	N/A
2060	1,804,405	1,529,969	N/A
2070	1,959,091	1,573,879	N/A
2080	2,142,389	1,622,202	N/A





Source: DWU_LRWSP_Draft Projection Tool Baseline Scenario 2023 Population Update_20230124_Submitted.xlsx, Modeled 2024-01-24

Figure 4. Final Population Model Parameters

The table below summarizes the updated water demand compared to the 2014 Long Range Water Supply Plan. There are several reasons for the difference between the forecast demands in 2014 and 2024, listed below. Additional details related to the 2014 vs. 2024 modeling comparison are provided in the Water Demand Forecast TM.

1) The end use modeling provided by the DSS Model represents a significant improvement to the per-capita approach employed during the 2014 modeling effort.
2) The ratio-based approach to allocating wholesale population and demand is significantly more precise than the full demands assigned during the 2014 forecast.
3) The more sophisticated GIS-based approach used in 2024 to generate the population forecast for the DWU retail service area represents an improvement over the TWDB population forecasts used in 2014, which extrapolated county-level growth observed from 2000-2010.

Projected Demands (MGD)			
Time Period	2014 Forecast	2024 Forecast	Difference
FY20	469	377*	-92
FY30	504	439	-65
FY40	558	438	-119
FY50	615	466	-149
FY60	679	495	-183
FY70	718	524	-193
FY80	N/A	559	N/A

**2024 Value for FY20 represents observed Demands from DWU data.*

Table 5. DWU 2024 Model Demands compared to 2014 Demands

APPENDIX A. POPULATION FORECAST BY PRESSURE ZONE

This appendix presents maps displaying current population (2023) and forecasted population for each decade (2030-2080) by Pressure Zone.

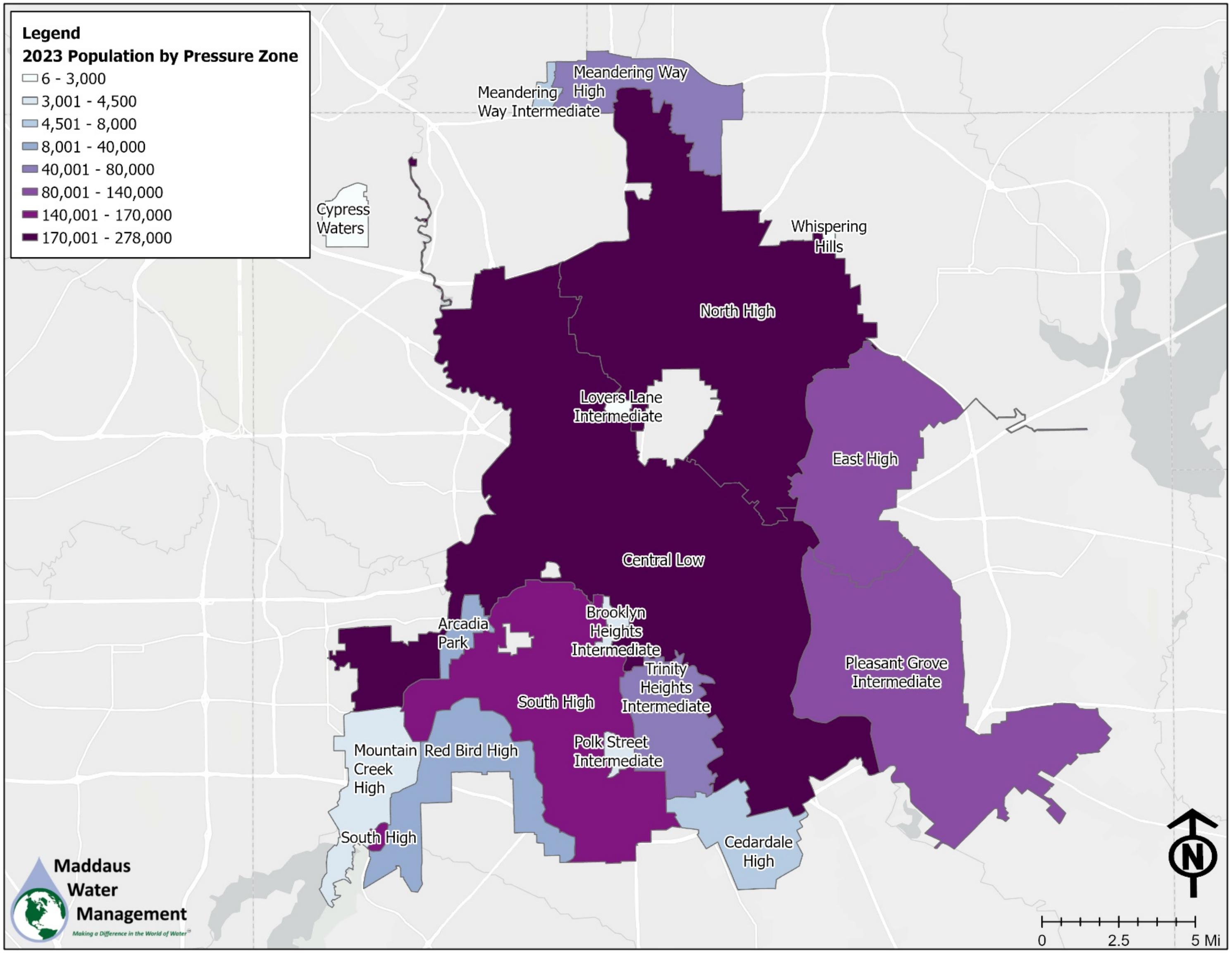


Figure A-1. 2023 Total Population by DWU Pressure Zone

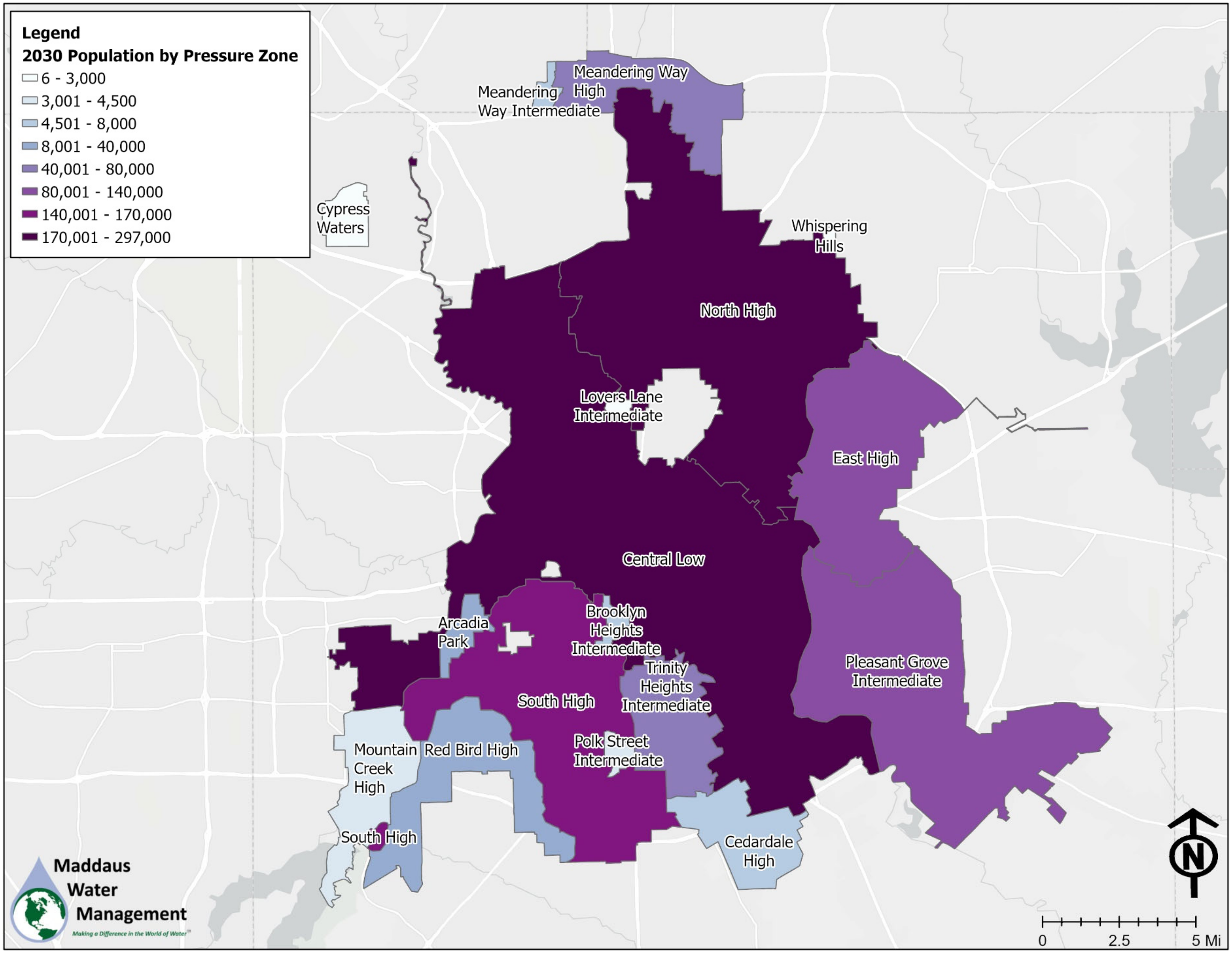


Figure A-2. 2030 Total Population by DWU Pressure Zone

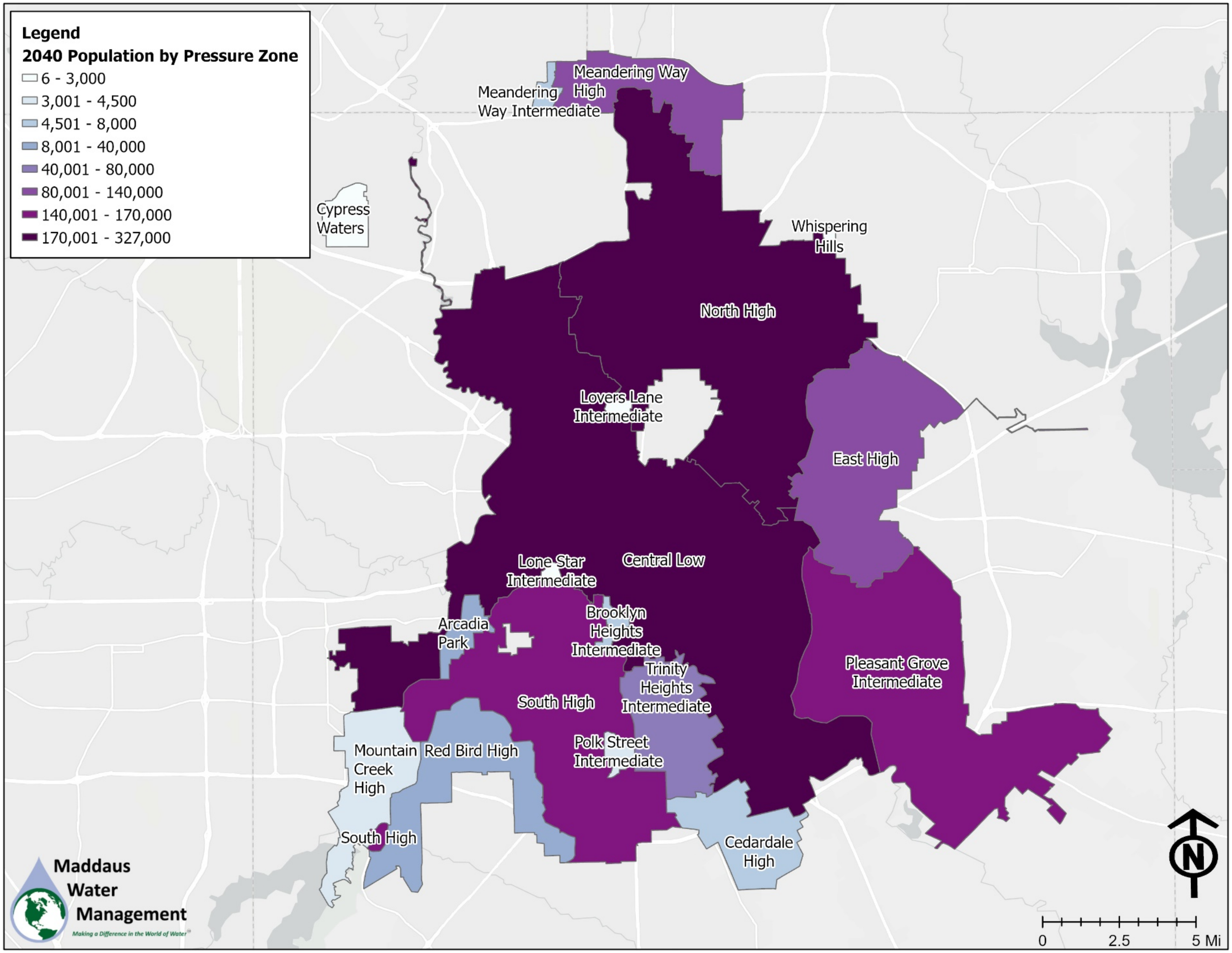


Figure A-3. 2040 Total Population by DWU Pressure Zone

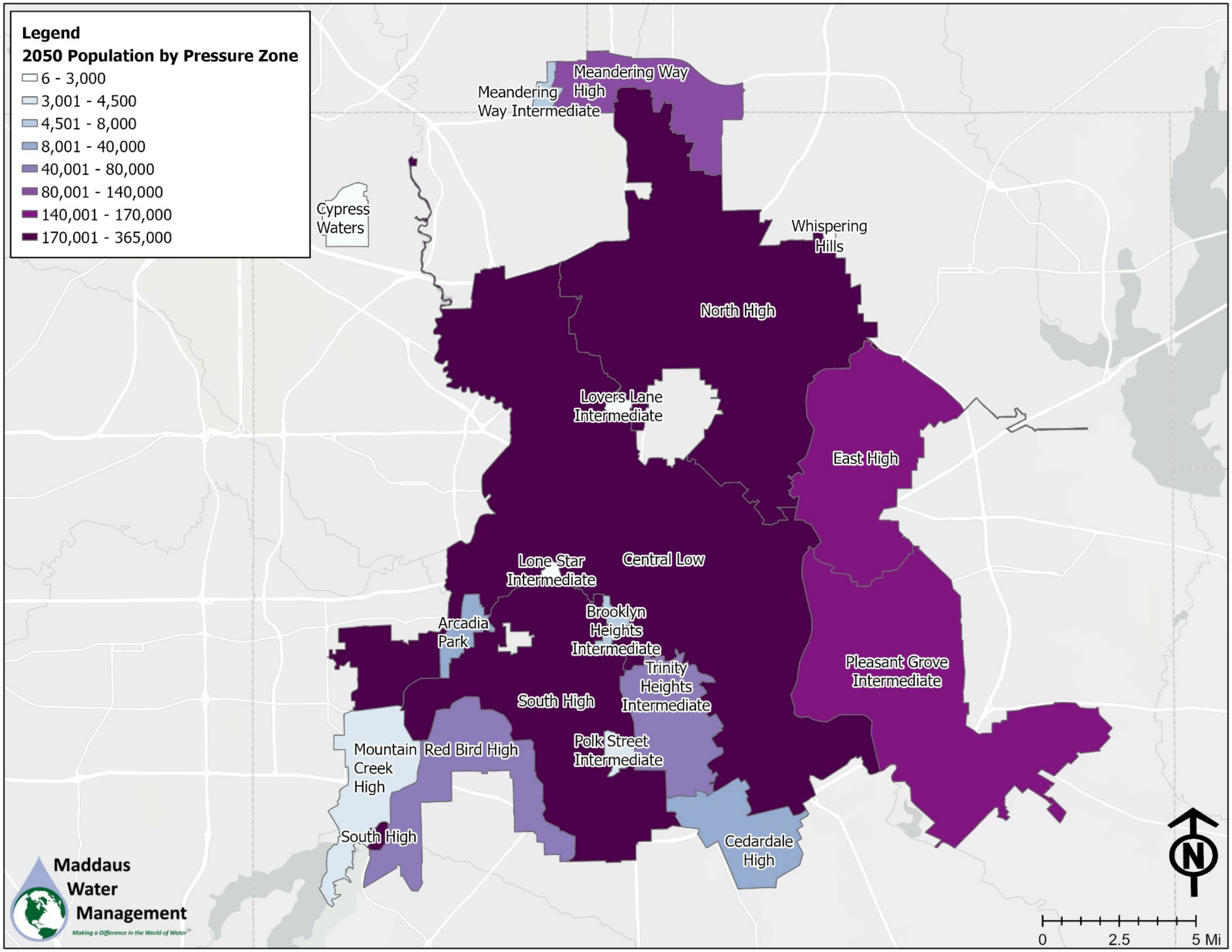


Figure A-4. 2050 Total Population by DWU Pressure Zone

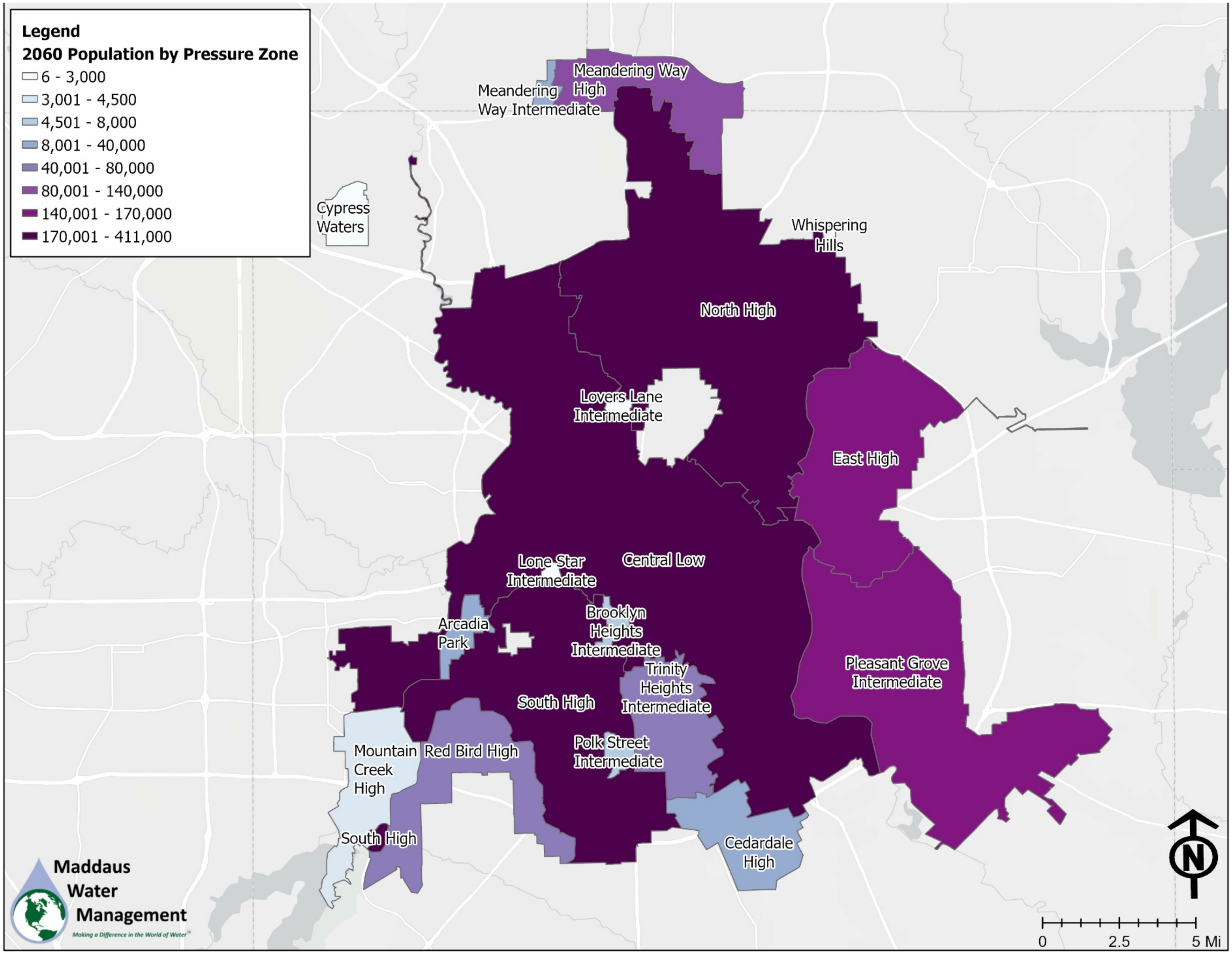


Figure A-5. 2060 Total Population by DWU Pressure Zone

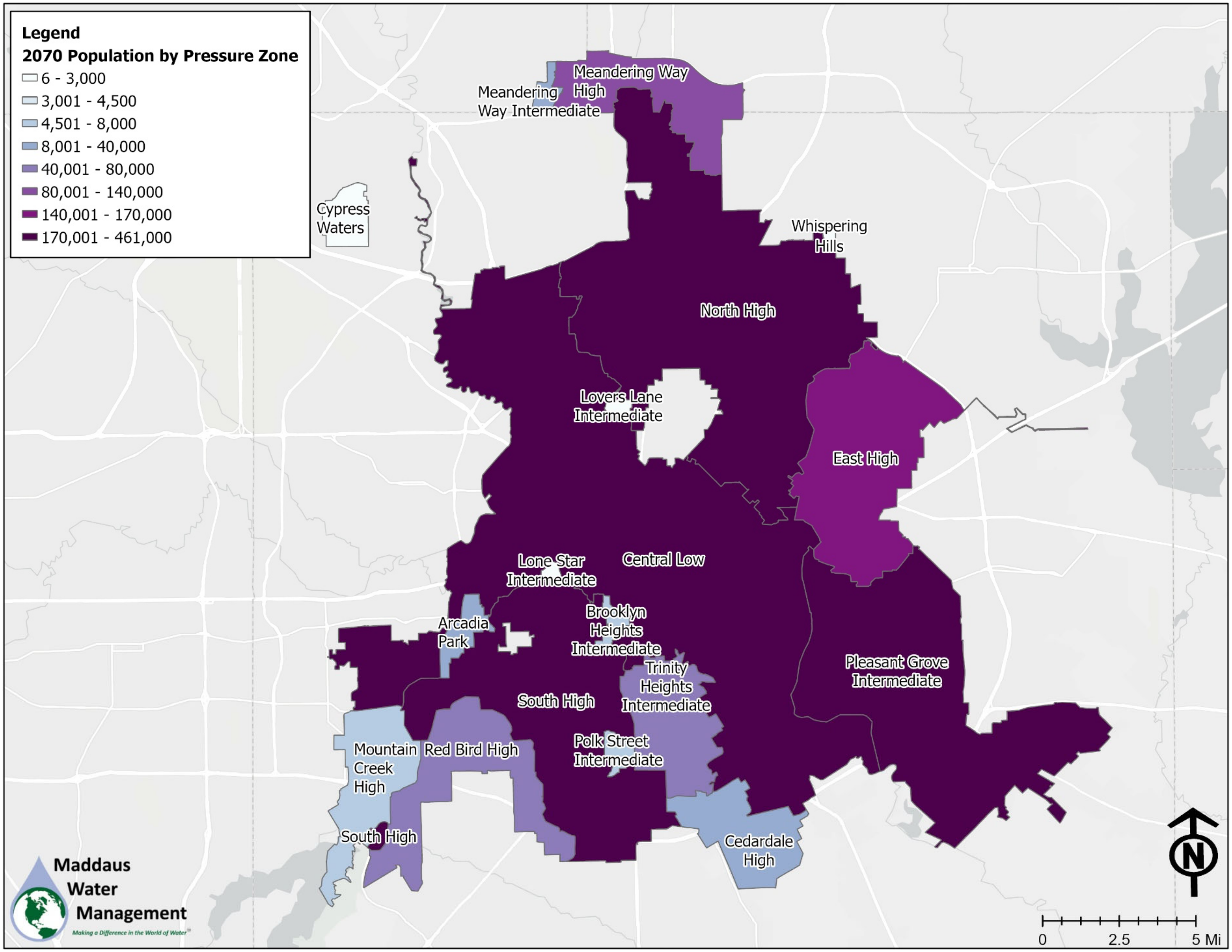


Figure A-6. 2070 Total Population by DWU Pressure Zone

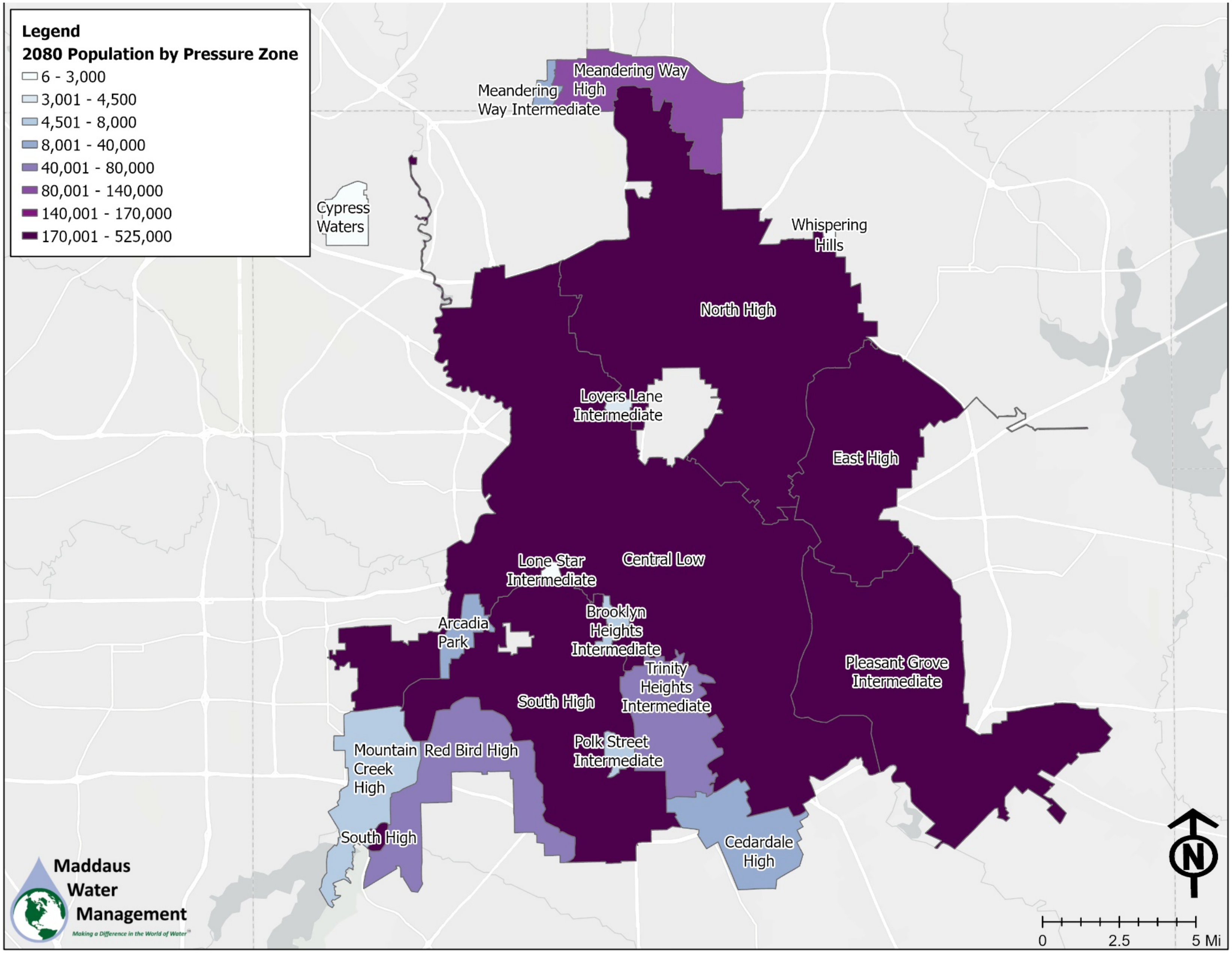


Figure A-7. 2080 Total Population by DWU Pressure Zone

APPENDIX B. BASELINE WATER DEMAND WITH PLUMBING CODE BY PRESSURE ZONE

This appendix presents maps of base year current water demands (2024) and forecasted demands for each decade (2030-2080) by Pressure Zone.

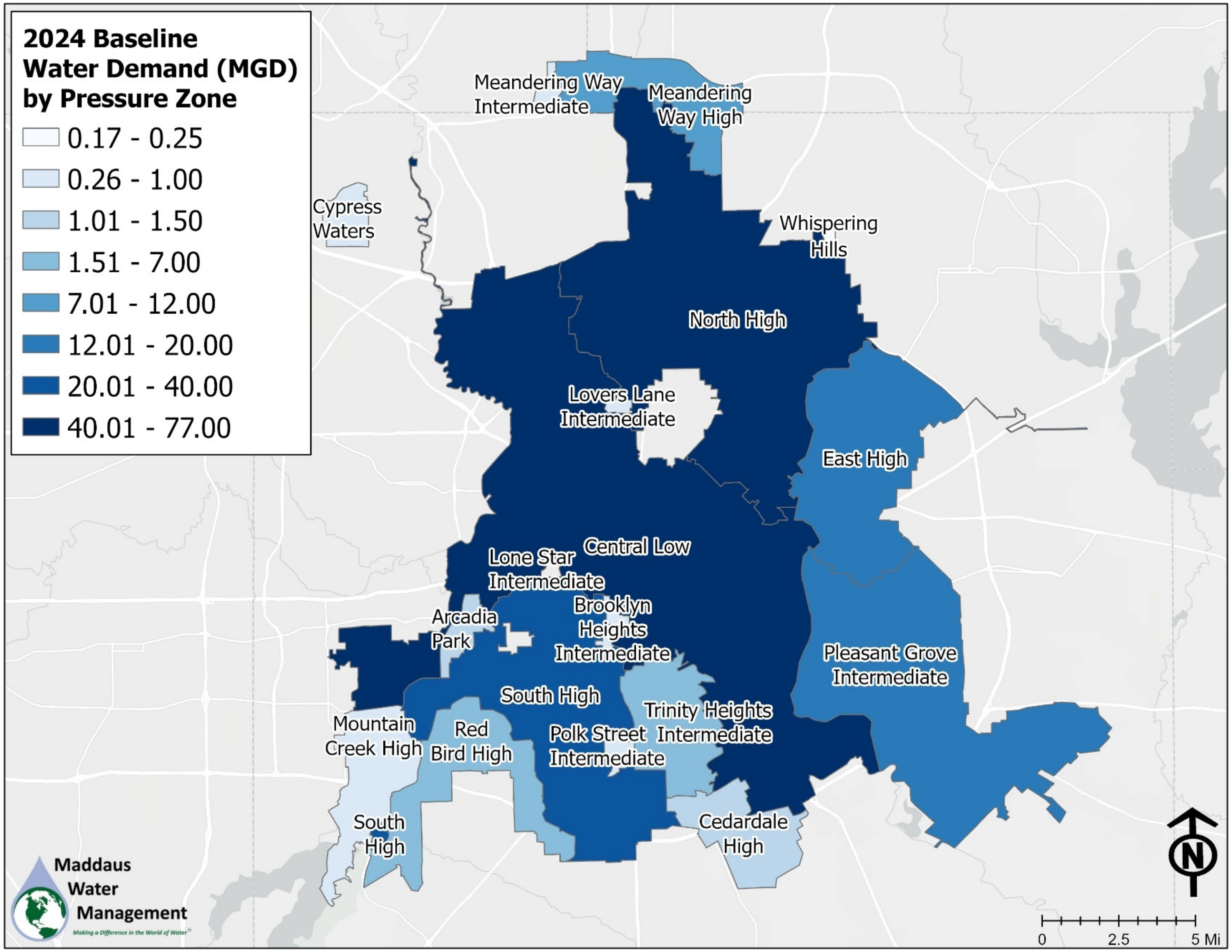


Figure B-1. 2024 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

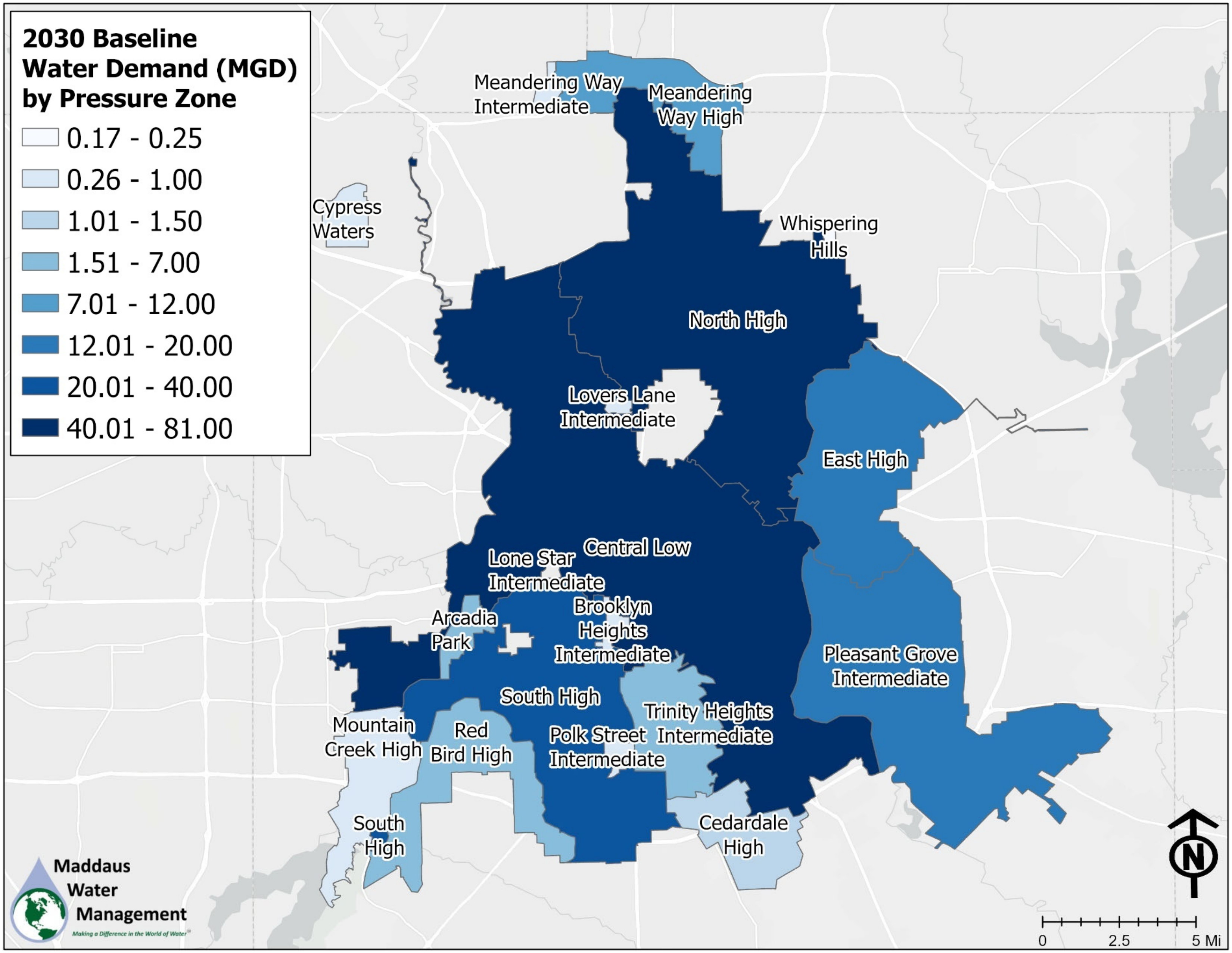


Figure B-2. 2030 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

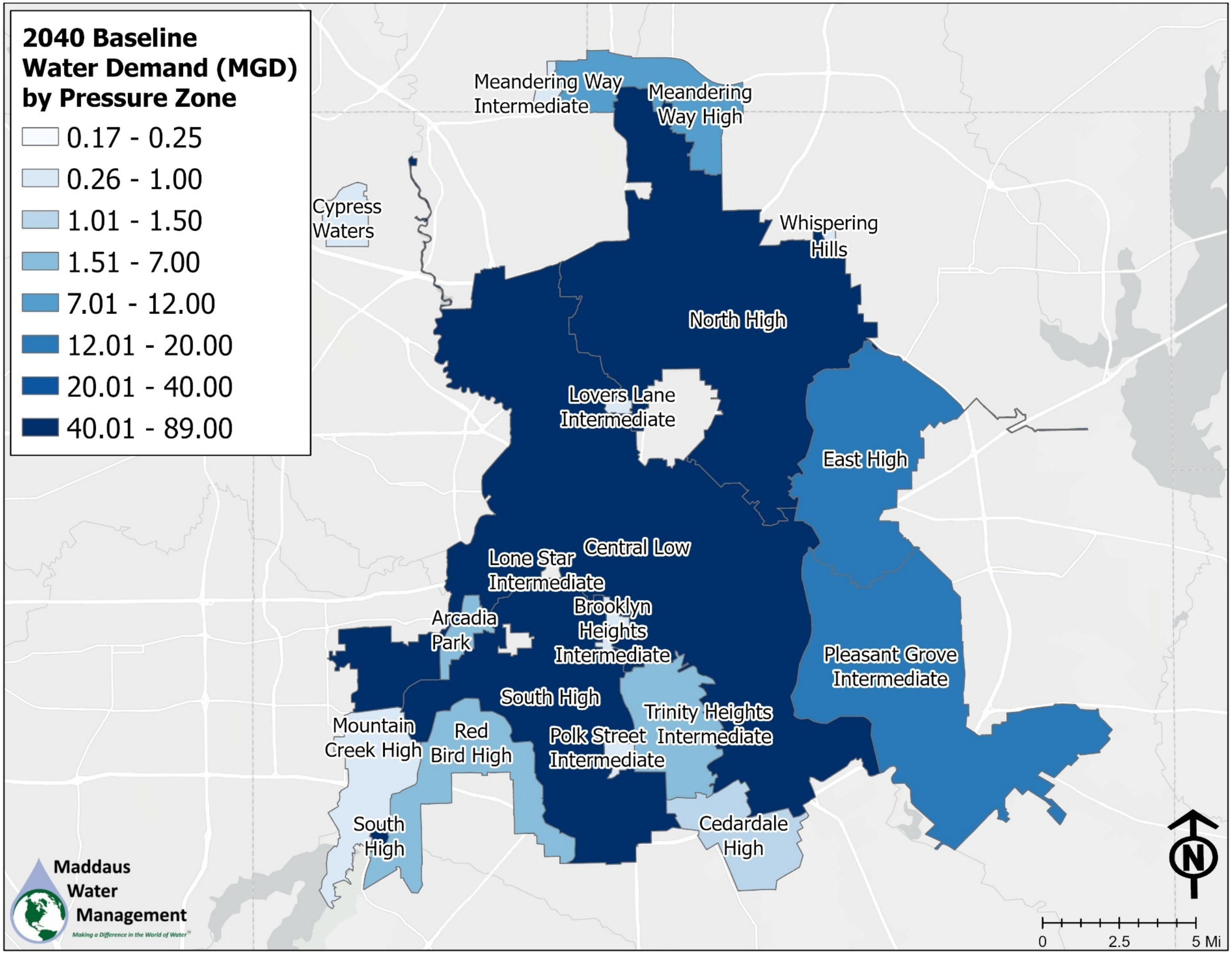


Figure B-3. 2040 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

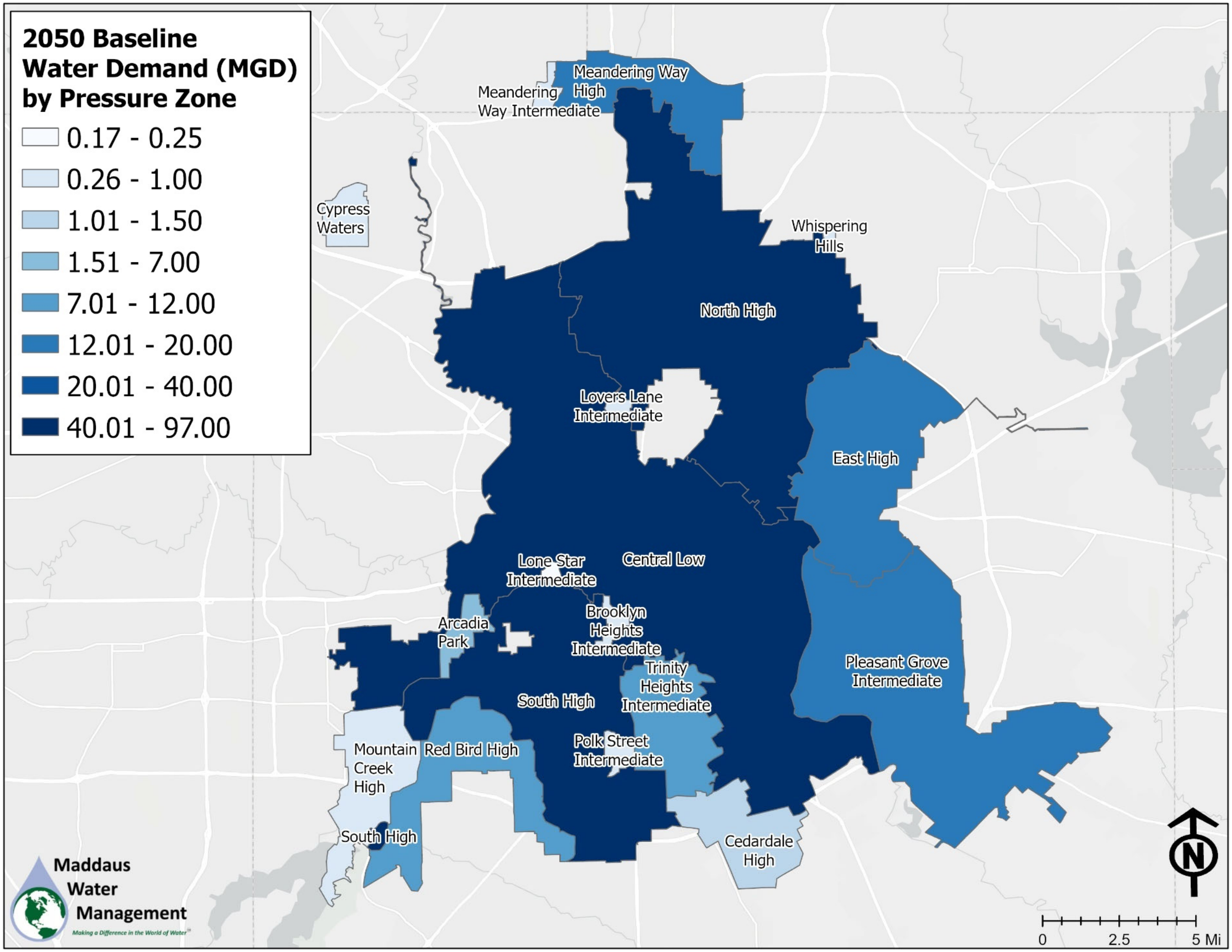


Figure B-4. 2050 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

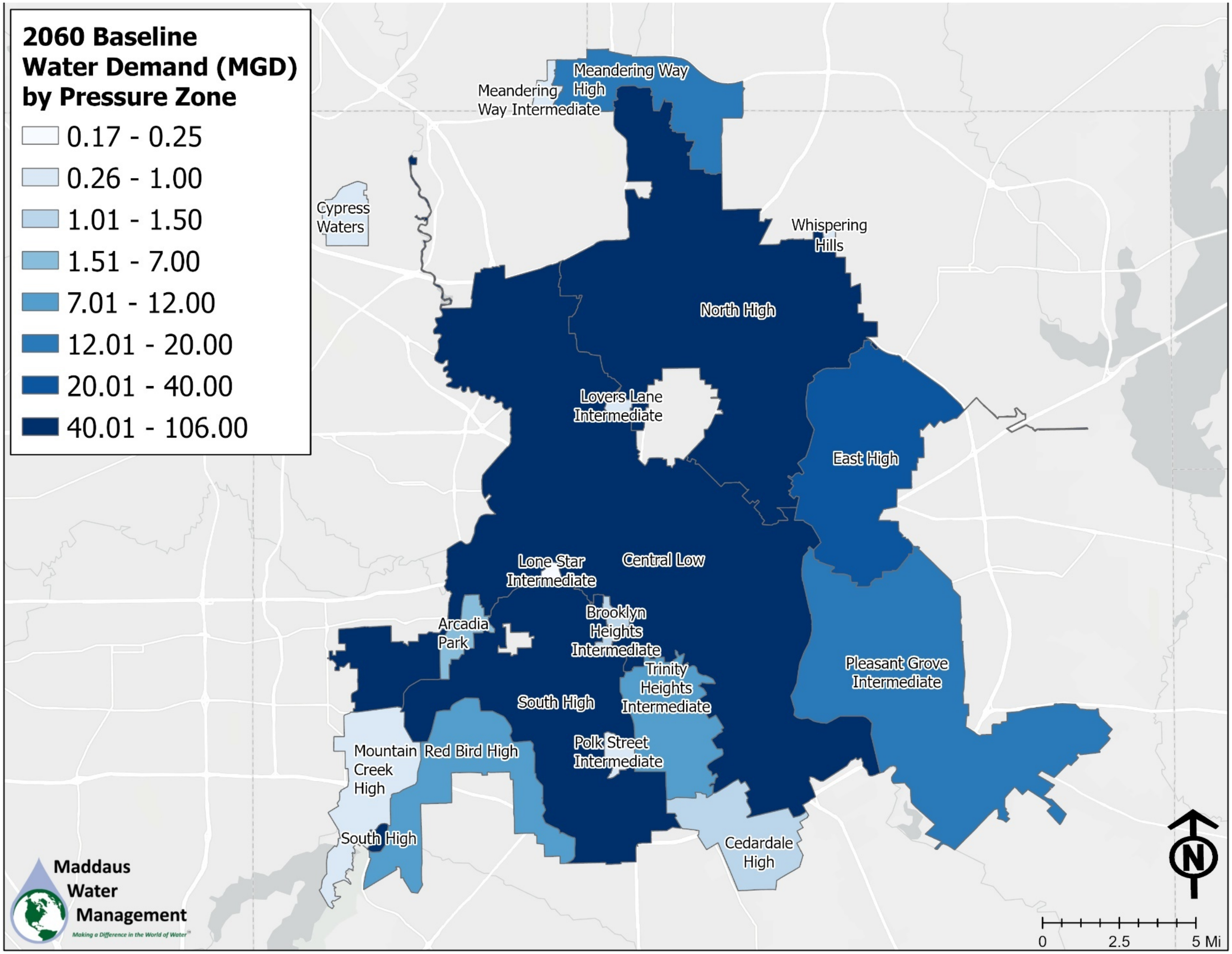


Figure B-5. 2060 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

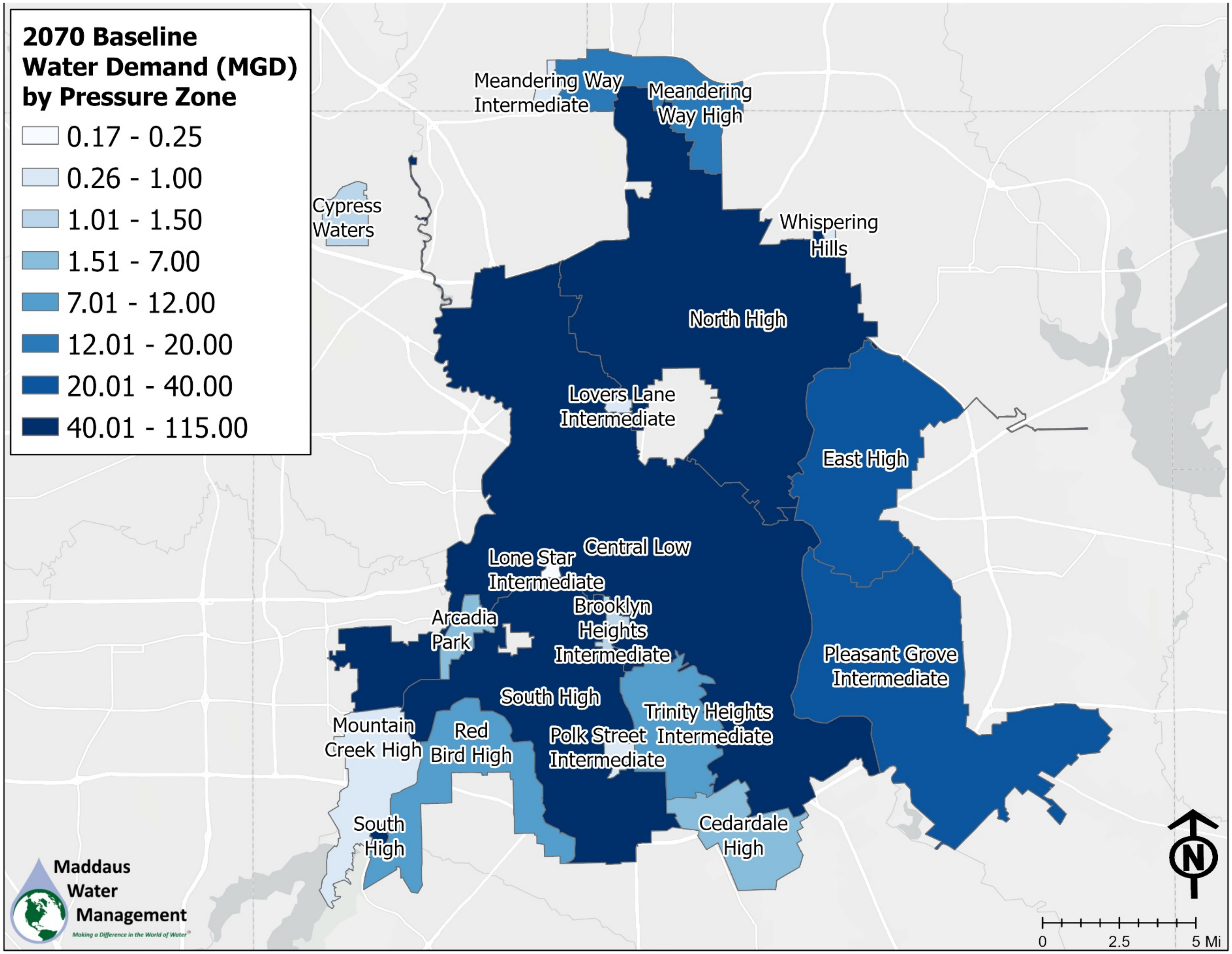


Figure B-6. 2070 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

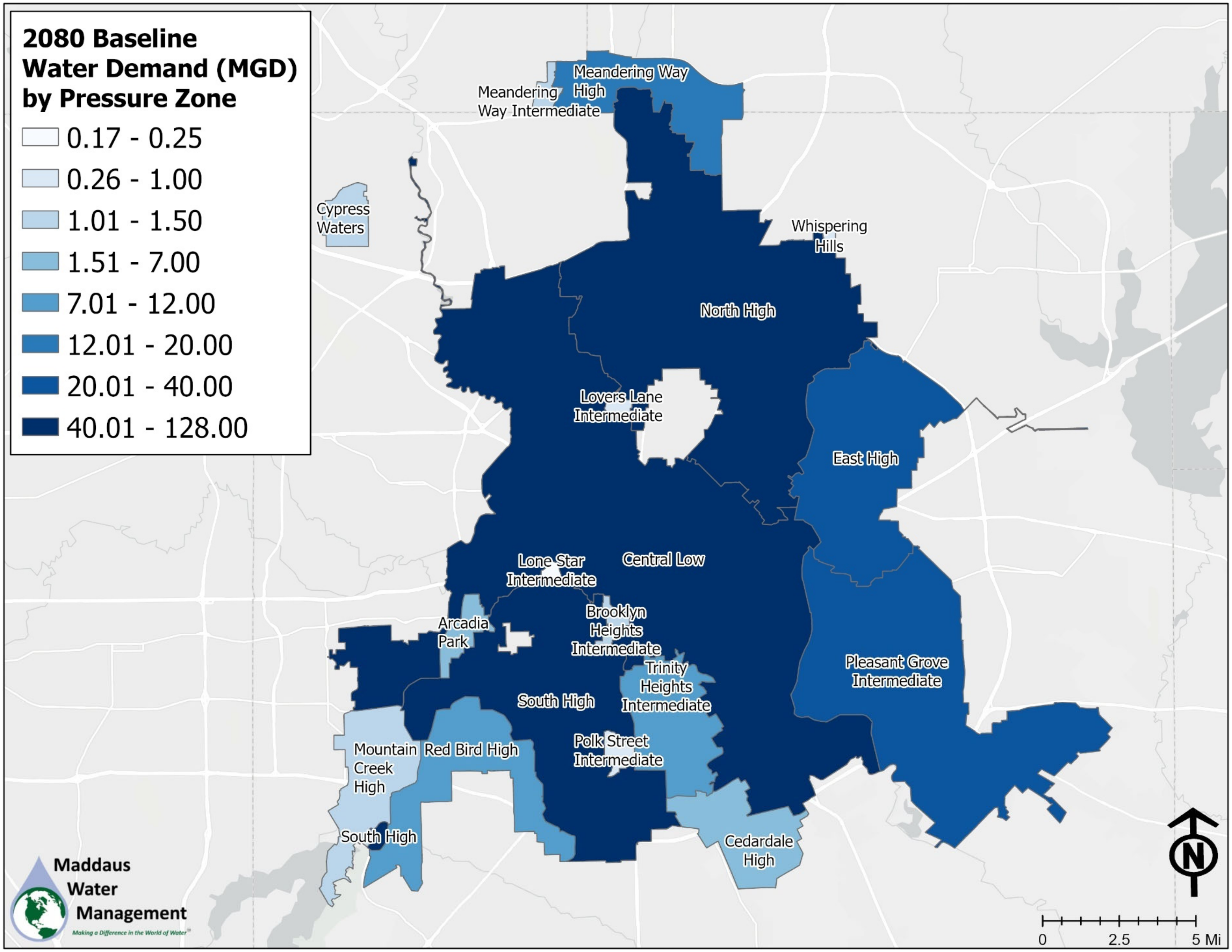


Figure B-7. 2080 Baseline Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

APPENDIX C. CONSERVATION PROGRAM B WATER DEMAND FORECAST BY PRESSURE ZONE

This appendix presents maps of base year current water demands (2024) and forecasted demands for each decade (2030-2080) by Pressure Zone.

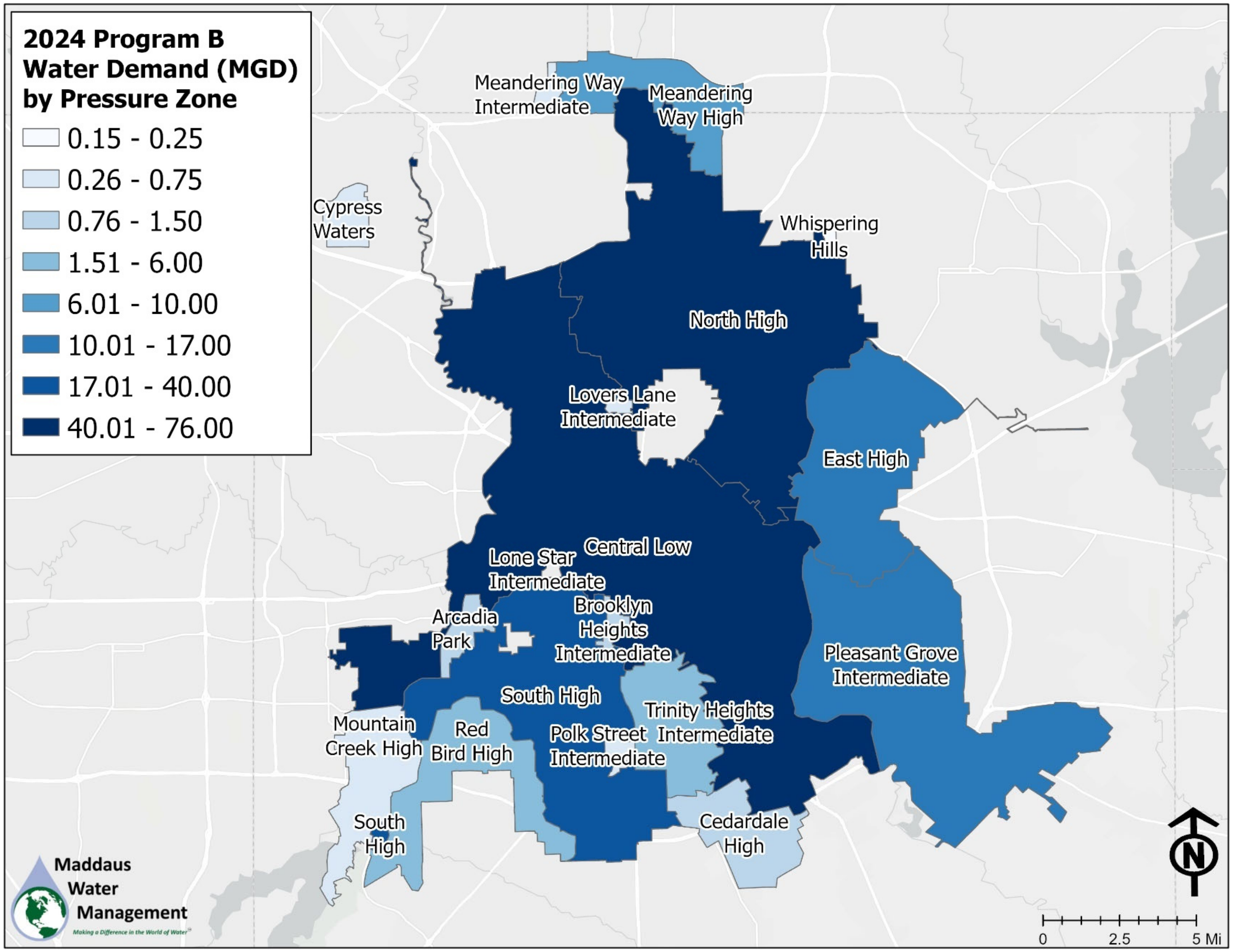


Figure C-1. 2024 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

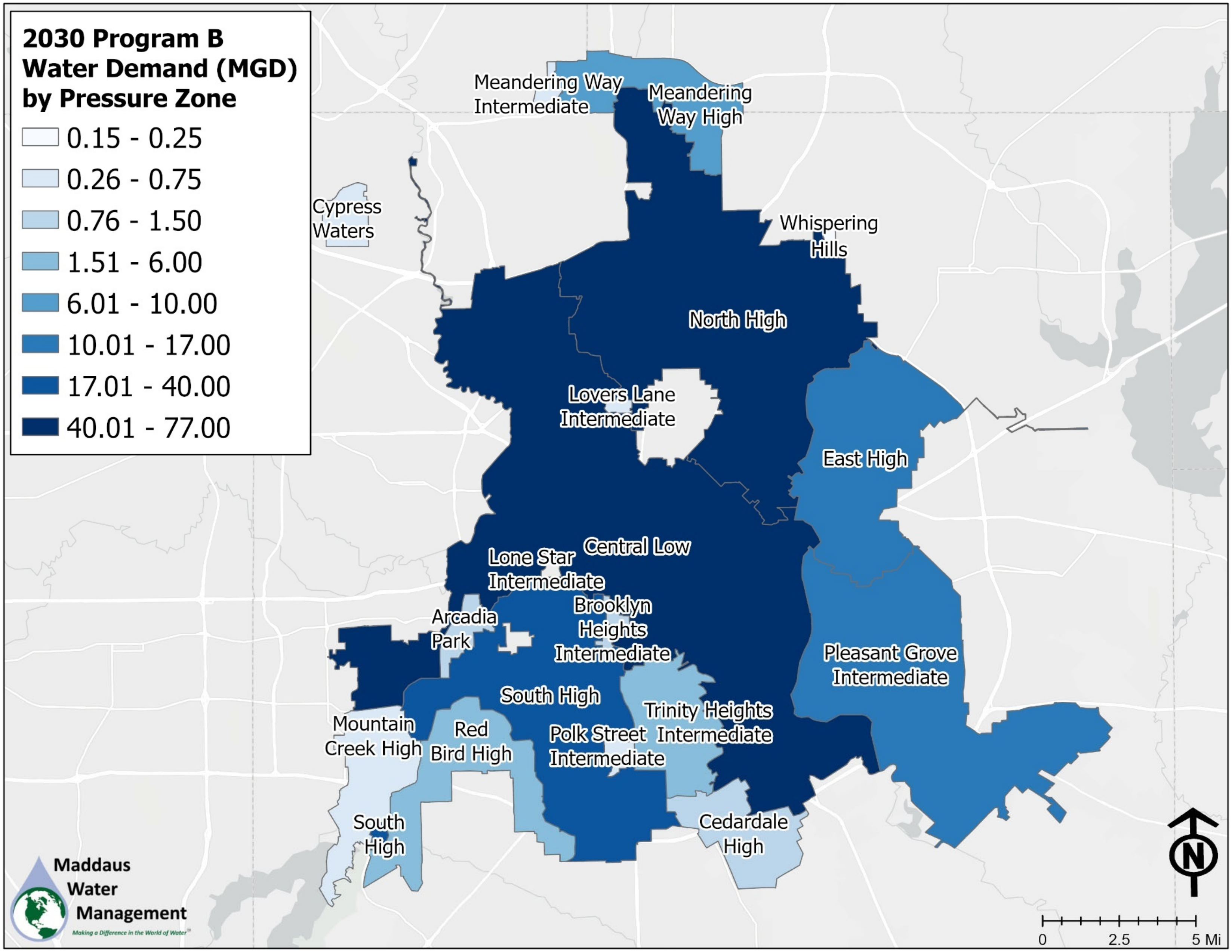


Figure C-2. 2030 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

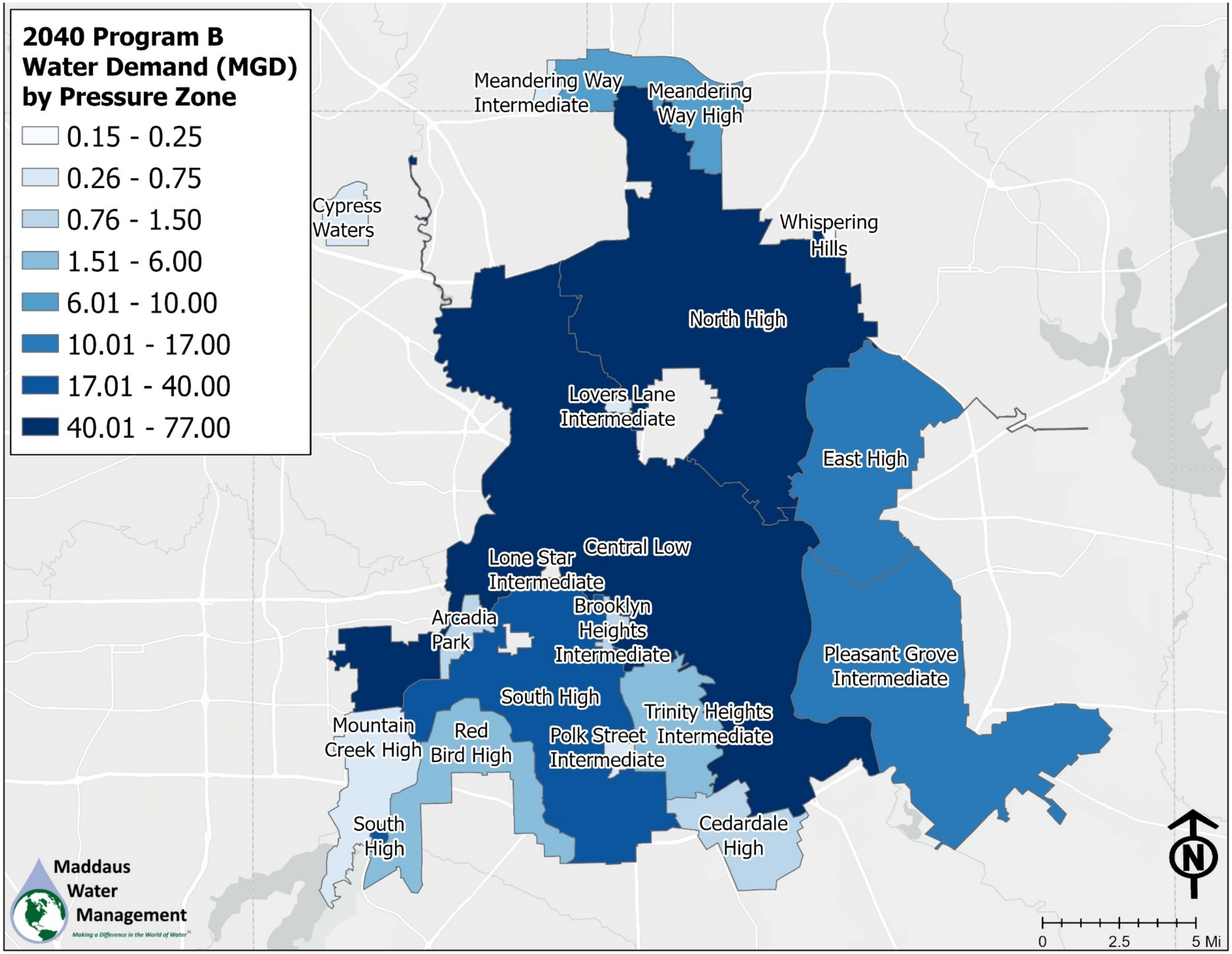


Figure C-3. 2040 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

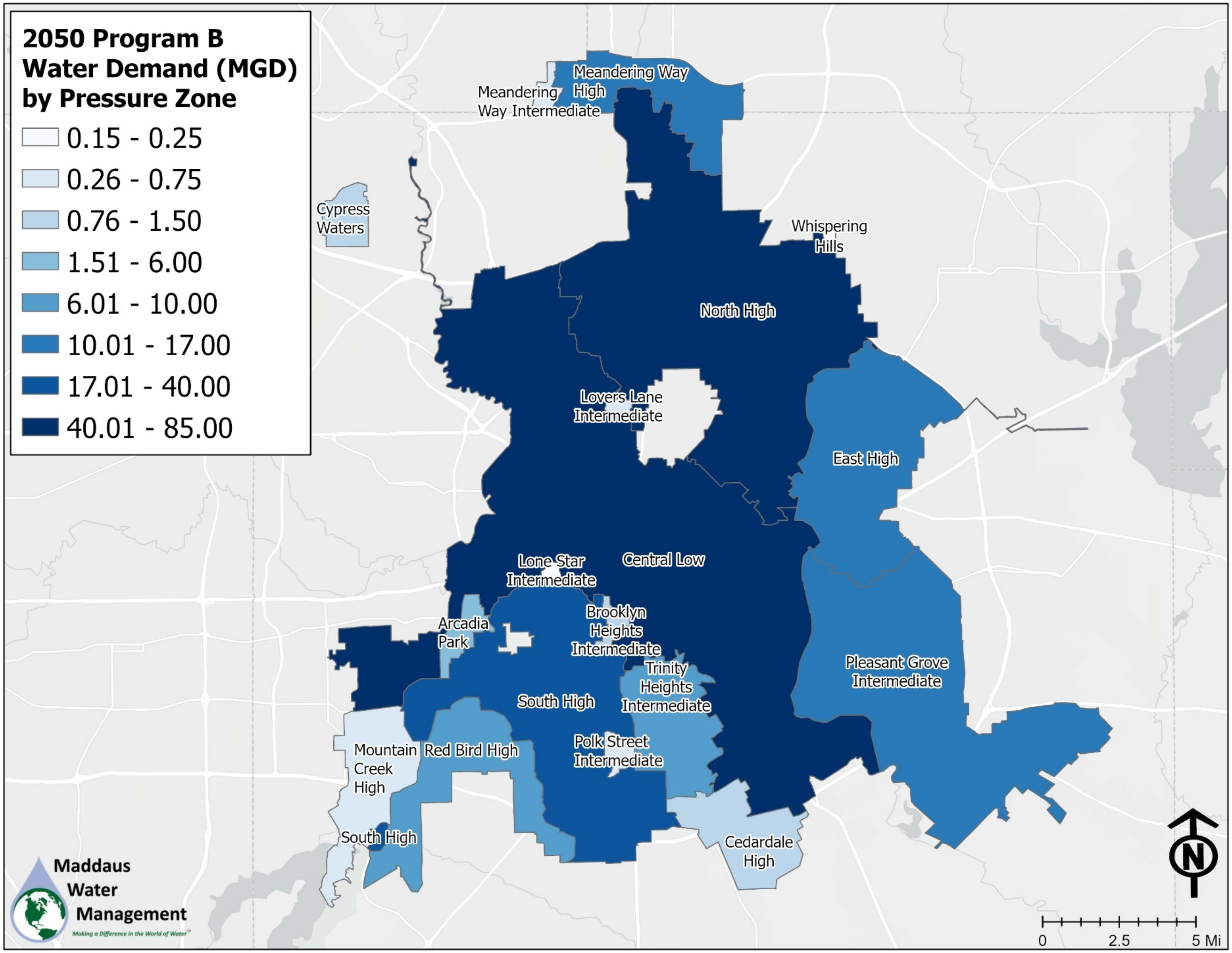


Figure C-4. 2050 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

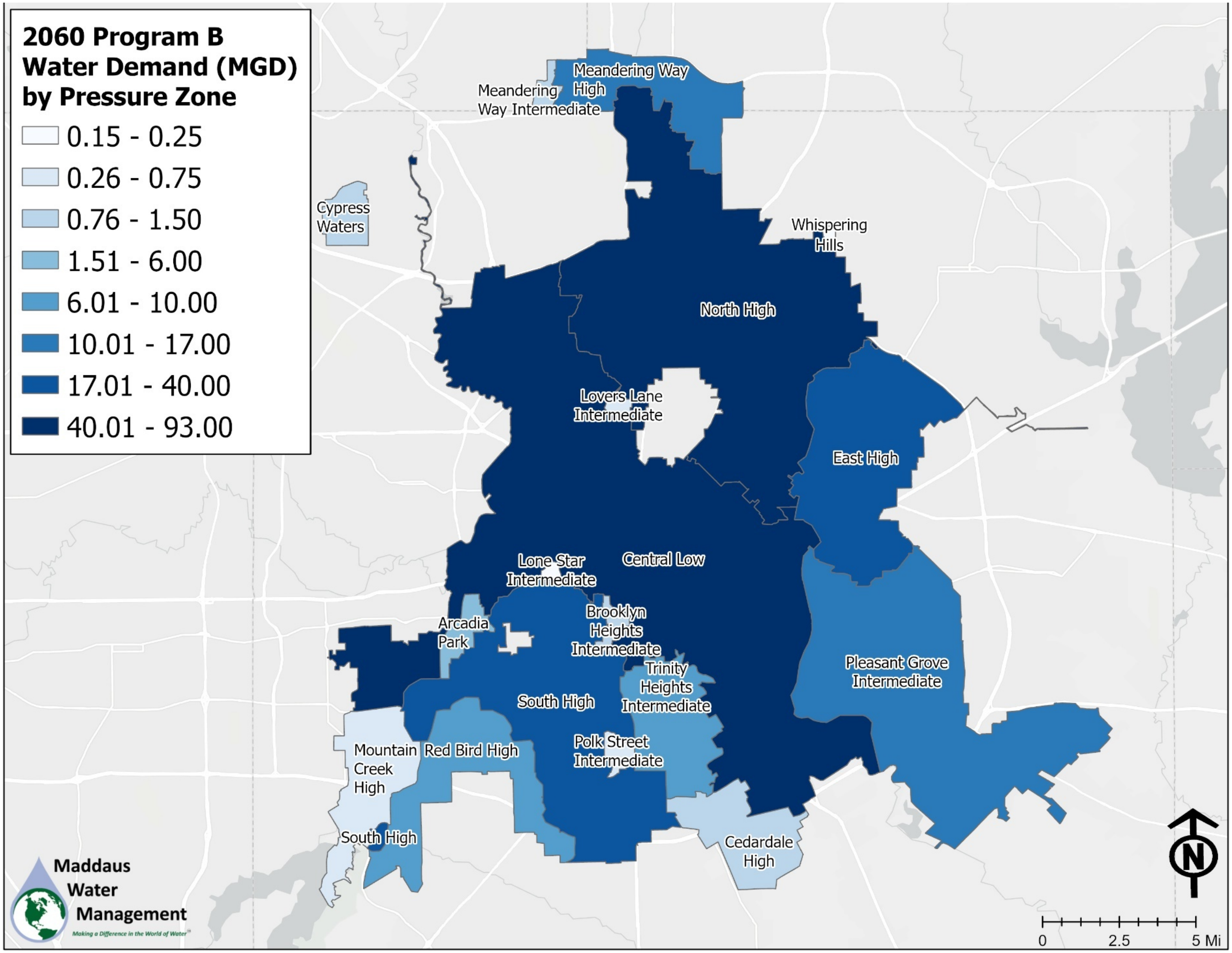


Figure C-5. 2060 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

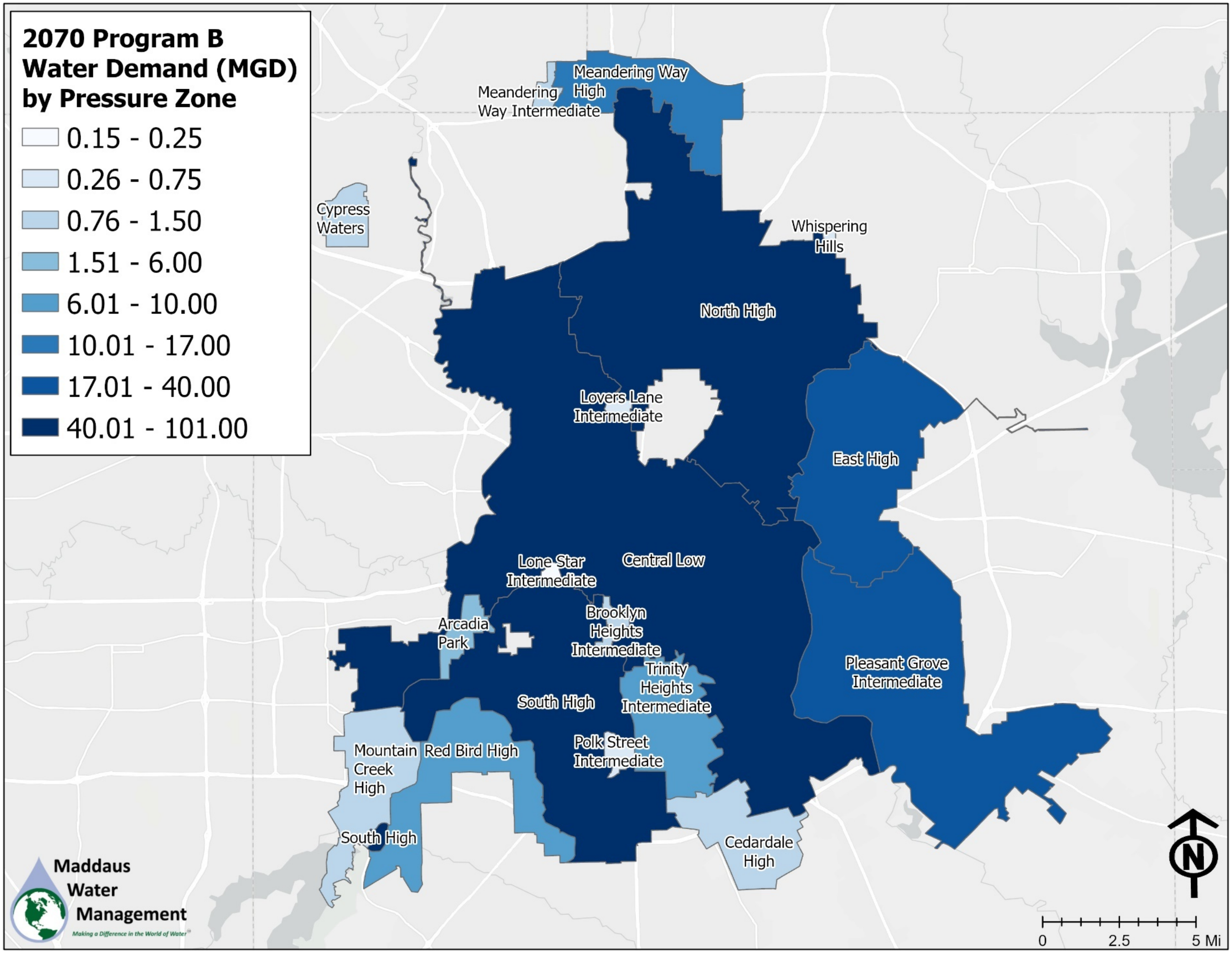


Figure C-6. 2070 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

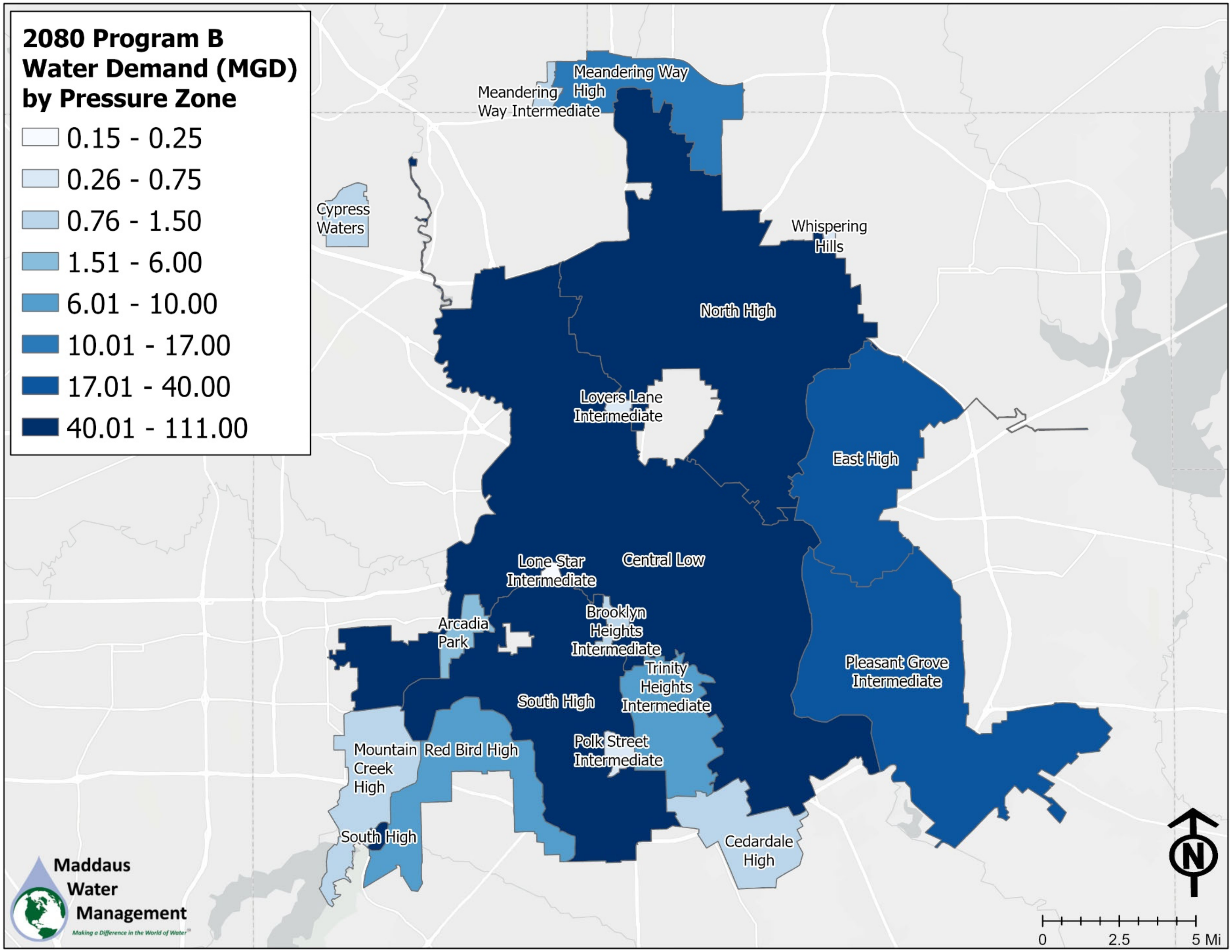


Figure C-7. 2080 Conservation Program B Water Demands (MGD) with Plumbing Code by DWU Pressure Zone

APPENDIX D. COMBINED WATER DEMAND FORECAST BY ENTITY

This appendix presents a summary of total water demand projections by entity and by pressure zone.

Table D-1. Water Demand Forecasts by Entity and Pressure Zone (Does not include Program B Water Conservation Savings)

	Projected Baseline with Plumbing Code Water Demand on Dallas (MGD)						
	2024	2030	2040	2050	2060	2070	2080
Demands (MGD) by DWU Pressure Zone							
Arcadia Park	1.5	1.6	1.7	1.8	1.9	2.0	2.1
Brooklyn Heights Intermediate	0.8	0.8	0.9	1.0	1.1	1.1	1.2
Cedardale High	1.2	1.2	1.3	1.4	1.5	1.6	1.7
Central Low	76.2	80.9	88.4	96.6	105.6	115.4	127.0
Cypress Waters	0.7	0.7	0.8	0.9	0.9	1.0	1.1
East High	15.9	16.7	17.7	18.9	20.1	21.2	22.6
Lone Star Intermediate	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Lovers Lane Intermediate	0.3	0.3	0.3	0.4	0.4	0.4	0.5
Meandering Way High	9.8	10.4	11.2	12.1	13.1	14.5	16.2
Meandering Way Intermediate	0.7	0.7	0.8	0.8	0.9	0.9	1.0
Mountain Creek High	0.8	0.6	0.7	0.8	0.8	0.9	1.0
North High	58.7	62.3	67.6	73.4	79.5	85.4	92.3
Pleasant Grove Intermediate	15.5	16.2	17.0	18.0	19.2	20.2	21.6
Polk Street Intermediate	0.5	0.5	0.5	0.6	0.6	0.6	0.6
Red Bird High	5.8	6.1	6.5	7.0	7.6	8.0	8.6
South High	36.6	38.2	40.0	42.4	44.8	47.2	50.1
Trinity Heights Intermediate	6.0	6.3	6.8	7.2	7.6	8.1	8.7
Whispering Hills	0.2	0.2	0.3	0.3	0.3	0.3	0.3
City of Dallas Total (A)	**231.3**	**244.1**	**262.7**	**283.6**	**306.0**	**329.3**	**356.9**
Treated Water Customer Demand (MGD) on Dallas							
Addison	5.4	7.4	8.4	8.9	9.1	9.5	9.8
Balch Springs	2.1	2.3	2.5	2.6	2.6	2.7	2.7
Carrolton	20.1	21.6	21.5	21.5	21.5	21.5	21.5
Cedar Hill	6.4	7.8	8.2	8.4	8.5	8.7	8.8
Cockrell Hill	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Combine WSC	0.3	0.3	0.3	0.4	0.4	0.5	0.6
DeSoto	8.7	9.0	9.5	9.8	10.0	10.2	10.5
DFW Airport	2.7	3.1	3.3	3.5	3.6	3.7	3.9
Duncanville	4.8	5.4	5.6	5.8	5.8	5.8	5.8
Farmers Branch	8.0	9.5	10.3	10.8	11.0	11.3	11.6
Flower Mound	5.4	7.0	8.8	10.6	12.5	14.6	16.9
Glenn Heights	2.1	2.1	2.4	2.7	3.0	3.3	3.7
Grand Prairie	17.5	20.4	21.0	21.3	21.5	21.8	22.0
Hutchins	1.3	1.6	1.8	1.9	2.0	2.0	2.1
Irving	13.9	18.4	19.3	19.3	19.3	19.3	19.3
Lancaster	6.5	6.6	7.0	7.2	7.3	7.5	7.6
Lancaster MUD 1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Wilmer	0.6	0.5	0.6	0.6	0.6	0.7	0.7
Lewisville	8.8	9.5	9.5	9.5	9.5	9.5	9.5
Denton County FWSD 1 A	2.1	2.6	3.5	3.5	3.5	3.5	3.5
Ovilla	0.7	1.1	1.4	1.7	2.1	2.4	2.8
Red Oak	1.3	1.6	1.9	2.4	2.8	3.2	3.8
Seagoville	1.8	2.0	2.2	2.3	2.3	2.4	2.5
The Colony	4.3	4.9	5.8	6.4	6.4	6.4	6.4
Treated Water Customers (B)	**125.1**	**145.3**	**155.3**	**161.6**	**166.1**	**171.1**	**176.5**
Untreated Water Customer Demand (MGD) on Dallas							
Coppell	8.8	9.9	9.8	9.8	9.8	9.8	9.8
Grapevine	0.6	0.8	0.8	0.8	0.8	0.8	0.8
Irving	10.7	14.2	14.9	14.9	14.9	14.9	14.9
Lewisville	7.7	8.4	8.3	8.3	8.3	8.3	8.3
UTWRD (Total)*	20.3	28.5	32.6	36.9	41.2	45.7	51.7
Irrigation**	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Untreated Water Customers (C)	**48.6**	**62.3**	**67.0**	**71.3**	**75.5**	**80.1**	**86.1**
Total Demand Treated and Untreated Water Customers (D)	**405.0**	**451.7**	**484.9**	**516.5**	**547.7**	**580.5**	**619.5**

*Includes Argyle WSC, Denton, Corinth, Flower Mound, Highland Village, Lake Cities Municipal Utility Authority, and 10 MGD additional contractual demand.
**Includes Carrollton-Farmers Branch ISD, Carrollton-Indian Creek Golf Course, Garland-Firewheel Golf Park, Hickory Creek-Arrowhead Park, Highland Village-Double Tree Ranch, Rowlett-Waterview Golf Course

Table D-2. Water Demand Forecasts including potential future DWU Customer Cities

	Projected Baseline with Plumbing Code Water Demand on Dallas (MGD)					
	2030	2040	2050	2060	2070	2080
City of Dallas Total (A)	244.1	262.7	283.6	306.0	329.3	356.9
Treated Water Customers (B)	145.3	155.3	161.6	166.1	171.1	176.5
Untreated Water Customers (C)	62.3	67.0	71.3	75.5	80.1	86.1
Potential Future Customer Demands (MGD)						
Ellis County WCID #1 (Waxahachie)	7.7	9.5	11.5	13.5	15.7	18.1
Heath	3.5	4.4	5.5	6.6	7.8	9.2
Sunnyvale	2.9	3.4	3.6	3.8	3.9	4.1
Gastonia Scurry SUD	0.8	1.0	1.3	1.7	2.1	2.5
Rockett SUD	3.8	4.2	4.8	5.6	6.8	8.0
Potential Future Customers Total (E)	18.7	22.6	26.7	31.1	36.2	41.9
Combined Potential Demands (F)	**470.4**	**507.5**	**543.2**	**578.8**	**616.7**	**661.4**

Appendix D. Population Projections by Entity

Projected City of Dallas Retail Customer Population (people)						
City of Dallas	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Arcadia Park	8,751	9,323	9,945	10,512	11,037	11,683
Brooklyn Heights Intermediate	4,529	4,911	5,540	6,196	6,770	7,408
Cedardale High	7,483	7,924	8,444	9,105	9,723	10,472
Central Low	296,123	326,330	364,196	410,473	460,692	521,129
Cypress Waters	1,474	1,633	1,815	2,052	2,285	2,587
East High	125,417	134,926	145,830	156,965	167,199	179,256
Lone Star Intermediate	0	6	21	64	93	134
Lovers Lane Intermediate	1,851	2,091	2,356	2,635	2,883	3,238
Meandering Way High	76,747	83,958	92,200	101,880	114,492	130,042
Meandering Way Intermediate	6,378	7,064	7,591	8,176	8,723	9,346
Mountain Creek High	3,046	3,259	3,605	4,030	4,536	5,201
North High	322,559	352,418	388,325	427,943	462,987	503,957
Pleasant Grove Intermediate	133,194	141,647	152,247	164,149	175,232	188,323
Polk Street Intermediate	4,012	4,233	4,420	4,598	4,767	4,966
Red Bird High	36,066	38,694	42,031	45,756	48,758	52,258
South High	315,882	335,556	360,768	387,084	411,847	440,311
Trinity Heights Intermediate	47,800	51,754	55,746	60,156	64,317	69,199
Whispering Hills	2,167	2,326	2,490	2,631	2,750	2,879
City of Dallas Retail Customers Total (A)	**1,393,479**	**1,508,053**	**1,647,570**	**1,804,405**	**1,959,091**	**2,142,389**
Projected DWU Treated Water Customer City Populations (people)						
Customer City	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Addison	20,465	23,069	24,456	25,276	26,179	27,173
Balch Springs (DCWCID #6)	28,412	30,394	33,234	36,214	40,018	42,000
Carrollton	141,268	149,561	158,341	167,636	177,477	178,153
Cedar Hill	53,645	58,553	63,911	69,070	74,646	80,672
Cockrell Hill	3,610	3,380	3,255	3,176	3,089	2,993
Combine WSC	3,604	4,094	4,678	5,309	6,009	6,784
Coppell	43,777	43,632	43,757	43,857	44,000	44,000
DFW Airport	NA	NA	NA	NA	NA	NA
DeSoto	59,901	63,934	66,069	67,304	68,664	70,162
Duncanville	43,672	45,939	47,157	47,307	47,307	47,307
Farmers Branch	36,454	39,795	41,570	42,609	43,754	45,014
Flower Mound *	95,690	119,876	145,420	145,481	145,555	145,555
Glenn Heights (Oak Leaf) *	22,178	25,909	29,228	32,297	35,668	39,377
Grand Prairie *	223,551	250,447	281,412	289,414	300,401	300,401
Hutchins	8,346	9,300	9,808	10,107	10,436	10,799
Irving *	285,073	302,931	303,163	303,400	303,641	303,641
Lancaster (w/ Lancaster MUD 1)	46,953	50,263	52,017	53,034	54,154	55,387
Wilmer	5,902	6,672	7,081	7,324	7,591	7,885

Lewisville (55% Treated) Inc Denton County FWSD 1 A	138,788	147,715	157,909	160,047	163,162	163,162
Ovilla	5,438	6,827	8,337	9,871	11,556	13,411
Red Oak	12,039	15,009	18,237	21,502	25,093	29,044
Seagoville	20,875	22,892	23,964	24,593	25,285	26,047
The Colony *	51,496	60,502	67,600	67,600	67,600	67,600
Total Treated Water Customers (B)	**1,351,137**	**1,480,694**	**1,590,604**	**1,632,428**	**1,681,285**	**1,706,567**
Projected DWU Untreated Water Customer City Populations (people)						
Customer City	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Grapevine *	54,037	54,037	54,037	54,037	54,037	54,037
Lewisville (45% Untreated)	Population Included Above					
UTRWD+ #	77,287	88,620	103,341	110,280	116,167	119,167
Irrigation	NA	NA	NA	NA	NA	NA
Total Untreated Water Customers (C)	**131,324**	**142,657**	**157,378**	**164,317**	**170,204**	**173,204**
Total Demand Treated and Untreated Water (D = A+B+C)	**2,875,940**	**3,131,404**	**3,395,552**	**3,601,150**	**3,810,580**	**4,022,160**

*** Indicates that Customer has multiple sources of water**

+ Indicates that only cities purchasing water sourced from DWU were included.

 # Indicates that Flower Mound was excluded due to being counted in the treated water customer city populations

This Page Intentionally Left Blank

Appendix E. Comparison of Water Demand Projections – 2014 LRWSP, 2026 Region C RWP, and 2024 LRSWP

Plan	2020	2030	2040	2050	2060	2070	2080
City of Addison							
2014 LRWSP	6,053	7,062	8,183	9,416	10,537	11,658	-
2026 Region C Plan	-	8,324	9,360	9,922	10,255	10,622	11,025
2024 LRWSP	-	8,324	9,360	9,922	10,255	10,622	11,025
City of Balch Springs							
2014 LRWSP	2,802	2,914	3,027	3,251	3,587	3,811	-
2026 Region C Plan	-	2,854	3,033	3,316	3,614	3,993	4,191
2024 LRWSP	-	2,854	3,033	3,316	3,614	3,993	4,191
City of Carrollton							
2014 LRWSP	23,540	23,540	23,092	22,867	22,867	22,867	-
2026 Region C Plan	-	25,669	27,059	28,648	30,330	32,110	32,233
2024 LRWSP	-	30,938	32,620	34,525	36,543	38,673	38,897
City of Cedar Hill							
2014 LRWSP	10,425	12,667	14,797	17,038	17,038	17,038	-
2026 Region C Plan	-	10,544	11,467	12,517	13,527	14,619	15,799
2024 LRWSP	-	10,544	11,467	12,517	13,527	14,619	15,799
City of Cockrell Hill							
2014 LRWSP	448	448	448	448	560	1,121	-
2026 Region C Plan	-	525	489	471	460	447	433
2024 LRWSP	-	560	560	560	560	560	448
Combine WSC							
2014 LRWSP	336	336	448	448	560	673	-
2026 Region C Plan	-	330	373	426	483	548	618
2024 LRWSP	-	330	373	426	483	548	618
City of Coppell							
2014 LRWSP	10,985	11,210	11,097	11,097	11,097	11,097	-
2026 Region C Plan	-	11,392	11,315	11,348	11,374	11,410	11,410
2024 LRWSP	-	14,348	14,236	14,236	14,348	14,348	14,348

*All values shown are in acft/yr.

Plan	2020	2030	2040	2050	2060	2070	2080
DFW Airport							
2014 LRWSP	2,914	3,139	3,475	3,811	4,260	4,596	-
2026 Region C Plan	-	-	-	-	-	-	-
2024 LRWSP	-	3,475	3,699	3,923	4,035	4,148	4,372
City of Dallas							
2014 LRWSP	275,305	292,344	326,869	361,506	389,194	402,757	-
2026 Region C Plan	-	296,261	308,913	323,564	338,933	355,192	372,319
2024 LRWSP	-	314,651	338,639	365,542	394,462	424,504	460,038
City of DeSoto							
2014 LRWSP	9,416	10,089	10,873	11,770	12,667	13,676	-
2026 Region C Plan	-	10,093	10,729	11,088	11,295	11,523	11,775
2024 LRWSP	-	13,563	14,460	14,909	15,245	15,581	15,917
City of Duncanville							
2014 LRWSP	6,053	6,389	6,277	6,165	6,165	6,165	-
2026 Region C Plan	-	6,037	6,319	6,487	6,507	6,507	6,507
2024 LRWSP	-	6,037	6,319	6,487	6,507	6,507	6,507
City of Farmers Branch							
2014 LRWSP	9,080	9,416	9,864	10,425	10,985	11,658	-
2026 Region C Plan	-	10,602	11,536	12,050	12,352	12,683	13,049
2024 LRWSP	-	10,602	11,536	12,050	12,352	12,683	13,049
City of Flower Mound							
2014 LRWSP	8,519	8,743	8,743	8,743	8,743	8,743	-
2026 Region C Plan	-	7,838	9,799	11,887	11,892	11,898	11,898
2024 LRWSP	-	7,838	9,799	11,887	11,892	11,898	11,898
City of Glenn Heights							
2014 LRWSP	1,681	2,354	2,914	3,587	4,372	5,941	-
2026 Region C Plan	-	2,334	2,714	3,061	3,383	3,736	4,125
2024 LRWSP	-	3,923	4,596	5,156	5,717	6,277	6,950

*All values shown are in acft/yr.

Plan	2020	2030	2040	2050	2060	2070	2080
City of Grand Prairie							
2014 LRWSP	21,971	31,162	34,077	33,965	33,516	33,629	-
2026 Region C Plan	-	24,965	27,823	31,263	32,153	33,374	33,374
2024 LRWSP	-	35,198	39,233	44,053	45,286	47,080	47,080
City of Grapevine							
2014 LRWSP	3,475	3,811	3,811	3,699	3,475	3,363	-
2026 Region C Plan	-	937	935	935	935	935	935
2024 LRWSP	-	897	897	897	897	897	897
City of Hutchins							
2014 LRWSP	1,009	1,345	1,794	2,130	2,578	2,914	-
2026 Region C Plan	-	1,841	2,037	2,148	2,214	2,286	2,365
2024 LRWSP	-	1,841	2,037	2,148	2,214	2,286	2,365
City of Irving							
2014 LRWSP	17,151	5,044	5,044	5,044	5,044	5,044	-
2026 Region C Plan	-	22,234	23,538	23,556	23,575	23,593	23,593
2024 LRWSP	-	22,234	23,538	23,556	23,575	23,593	23,593
City of Lancaster/Lancaster MUD 1							
2014 LRWSP	7,622	9,640	11,322	12,555	13,788	15,133	-
2026 Region C Plan	-	7,702	8,188	8,464	8,624	8,800	8,994
2024 LRWSP	-	12,106	12,891	13,339	13,563	13,900	14,236
City of Wilmer							
2014 LRWSP	448	448	673	1,345	2,018	3,811	-
2026 Region C Plan	-	814	913	969	1,003	1,039	1,079
2024 LRWSP	-	814	913	969	1,003	1,039	1,079
City of Lewisville (inc. Denton County FWSD 1-A)							
2014 LRWSP	21,410	24,549	27,912	31,275	34,525	34,525	-
2026 Region C Plan	-	23,384	24,794	26,504	26,862	27,385	27,385
2024 LRWSP	-	23,384	24,794	26,504	26,862	27,385	27,385

*All values shown are in acft/yr.

Plan	2020	2030	2040	2050	2060	2070	2080
City of Ovilla							
2014 LRWSP	1,121	1,345	1,681	2,018	2,466	4,596	
2026 Region C Plan		1,278	1,602	1,956	2,316	2,712	3,148
2024 LRWSP		1,278	1,602	1,956	2,316	2,712	3,148
City of Red Oak							
2014 LRWSP	112	112	448	785	1,009	1,906	
2026 Region C Plan		1,753	2,177	2,645	3,119	3,640	4,213
2024 LRWSP		2,466	2,914	3,475	4,035	4,708	5,381
City of Seagoville							
2014 LRWSP	2,018	2,466	2,802	3,139	3,587	3,587	
2026 Region C Plan		2,217	2,416	2,529	2,596	2,669	2,749
2024 LRWSP		2,217	2,416	2,529	2,596	2,669	2,749
City of The Colony							
2014 LRWSP	6,614	6,614	6,950	7,510	7,286	7,062	
2026 Region C Plan		5,499	6,436	7,191	7,191	7,191	7,191
2024 LRWSP		5,499	6,436	7,191	7,191	7,191	7,191
Upper Trinity Municipal Water District							
2014 LRWSP	38,336	46,632	48,089	49,546	60,307	60,531	
2026 Region C Plan		38,785	44,838	51,676	53,245	54,590	55,263
2024 LRWSP		38,785	44,838	51,676	53,245	54,590	55,263
DWU Total Customer Municipal Demand							
2014 LRWSP	488,846	523,820	574,711	623,584	672,234	697,903	
2026 Region C Plan		524,213	558,803	594,621	618,237	643,502	665,670
2024 LRWSP		574,707	623,207	673,750	712,325	753,012	794,424

*All values shown are in acft/yr.

This Page Intentionally Left Blank

Appendix F. Summary of Total Water Demand Projections by Entity

Projected City of Dallas Treated Water Demand on DWU Water Supply System (MGD)						
City of Dallas	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Arcadia Park	1.9	2	2.1	2.2	2.3	2.4
Brooklyn Heights Intermediate	0.9	1	1.1	1.3	1.3	1.4
Cedardale High	1.4	1.5	1.6	1.7	1.9	2
Central Low	93.1	101.7	111.1	121.4	132.7	146.1
Cypress Waters	0.8	0.9	1	1	1.2	1.3
East High	19.2	20.4	21.7	23.1	24.4	26
Lone Star Intermediate	0.1	0.2	0.2	0.2	0.2	0.2
Lovers Lane Intermediate	0.4	0.3	0.5	0.5	0.5	0.6
Meandering Way High	12	12.9	13.9	15.1	16.8	18.6
Meandering Way Intermediate	0.8	0.9	0.9	1	1	1.2
Mountain Creek High	0.7	0.8	0.9	0.9	1	1.2
North High	71.7	77.7	84.4	91.5	98.2	106.1
Pleasant Grove Intermediate	18.7	19.6	20.7	22.1	23.3	24.8
Polk Street Intermediate	0.6	0.6	0.7	0.7	0.7	0.7
Red Bird High	7	7.5	8	8.7	9.2	9.9
South High	43.9	46	48.7	51.5	54.3	57.6
Trinity Heights Intermediate	7.3	7.8	8.3	8.7	9.4	10
Whispering Hills	0.2	0.3	0.3	0.3	0.3	0.3
City of Dallas Total (A)	**280.7**	**302.1**	**326.1**	**351.9**	**378.7**	**410.4**
Projected Treated Water Customer Demand on DWU Water Supply System (MGD)						
Customer City	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Addison	7.4	8.4	8.9	9.1	9.5	9.8
Balch Springs (DCWCID #6)	2.5	2.7	3	3.2	3.6	3.7
Carrollton	27.6	29.1	30.8	32.6	34.5	34.7
Cedar Hill	9.4	10.2	11.2	12.1	13	14.1
Cockrell Hill	0.5	0.5	0.5	0.5	0.5	0.4
Combine WSC	0.3	0.3	0.4	0.4	0.5	0.6
Coppell	12.8	12.7	12.7	12.8	12.8	12.8
DFW Airport	3.1	3.3	3.5	3.6	3.7	3.9
DeSoto	12.1	12.9	13.3	13.6	13.9	14.2
Duncanville	5.4	5.6	5.8	5.8	5.8	5.8
Farmers Branch	9.5	10.3	10.7	11	11.3	11.6
Flower Mound *	7	8.7	10.6	10.6	10.6	10.6
Glenn Heights (Oak Leaf) *	3.5	4.1	4.6	5.1	5.6	6.2
Grand Prairie *	31.4	35	39.3	40.4	42	42
Hutchins	1.6	1.8	1.9	2	2	2.1
Irving *	19.8	21	21	21	21.1	21.1

Lancaster (w/ Lancaster MUD 1)	10.8	11.5	11.9	12.1	12.4	12.7
Wilmer	0.7	0.8	0.9	0.9	0.9	1
Lewisville (55% Treated) Inc Denton County FWSD 1 A	11.4	12.1	12.9	13.1	13.4	13.4
Ovilla	1.1	1.4	1.7	2.1	2.4	2.8
Red Oak	2.2	2.6	3.1	3.6	4.2	4.8
Seagoville	2	2.2	2.3	2.3	2.4	2.5
The Colony *	4.9	5.7	6.4	6.4	6.4	6.4
Total Treated Water Customers (B)	**187.0**	**202.9**	**217.4**	**224.3**	**232.5**	**237.2**
Projected Untreated Water Customer Demand on DWU Water Supply System (MGD)						
Customer City	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Grapevine *	0.8	0.8	0.8	0.8	0.8	0.8
Lewisville (45% Untreated)	9.4	10	10.6	10.8	11	11
UTRWD	34.6	40	46.1	47.5	48.7	49.3
Irrigation	0.6	0.6	0.6	0.6	0.6	0.6
Total Untreated Water Customers (C)	**45.4**	**51.4**	**58.1**	**59.7**	**61.1**	**61.7**
Total Demand Treated and Untreated Water (D = A+B+C)	**513.1**	**556.4**	**601.6**	**635.9**	**672.3**	**709.3**

*** Indicates that Customer has multiple sources of water. See Appendix page F-3 for their total demands and adjustments to account for these other supplies.**

Customer City-	2030	2040	2050	2060	2070	2080
Projected Total Treated Water Demand from Customers with Multiple Sources (MGD)						
Flower Mound	21.2	26.5	32.1	32.1	32.2	32.2
Glenn Heights (Oak Leaf)	3.6	4.1	4.7	5.2	5.7	6.3
Grand Prairie	44.2	49.3	55.4	57.0	59.1	59.1
Irving	53.6	56.8	56.8	56.8	56.9	56.9
The Colony	6.8	8	8.9	8.9	8.9	8.9
Projected Treated Water Demand on DWU Water Supply System from Customers with Multiple Sources (MGD)						
Flower Mound	7	8.7	10.6	10.6	10.6	10.6
Glenn Heights (Oak Leaf)	3.5	4.1	4.6	5.1	5.6	6.2
Grand Prairie	31.4	35	39.3	40.4	42	42
Irving	19.8	21	21	21	21.1	21.1
The Colony	4.9	5.7	6.4	6.4	6.4	6.4
Projected Total Untreated Water Demand from Customers with Multiple Sources (MGD)						
Grapevine	16.7	16.7	16.7	16.7	16.7	16.7
Projected Total Untreated Water Demand on DWU Water Supply System from Customers with Multiple Sources (MGD)						
Grapevine	0.8	0.8	0.8	0.8	0.8	0.8

This Page Intentionally Left Blank.

Appendix G. Additional Water Rights Owned by the City of Dallas

Table G-1 Summary of Additional Water Rights Owned By the City of Dallas

Reservoir	River Basin	Reservoir Owner or Permit Holder	Certificate of Adjudication No.	Priority Date(s)	Dallas Portion of Authorized Diversions MGD (acft/yr)
Elm Fork Run-of-River Diversion	Trinity	Dallas Parks & Rec Dept (L. B. Houston Golf Course)	08-2459	Jan-1952	0.04 (50)
Multiple City Park Ponds	Trinity	Dallas Parks & Rec Dept	08-2460	Sep-1958	0 (0)
Pond on Bear Creek	Trinity	Dallas & Ft. Worth	08-3800	Jan-1981	0.5 (610)
Pond on White Rock Creek	Trinity	Dallas Parks & Rec Dept (Tenison Golf Course)	5448	Feb-1993	0 (0)
Cherrybrook Lake	Trinity	Dallas Parks & Rec Dept	5464	Jun-1993	0 (0)
Crawford Elam Lake	Trinity	Dallas Parks & Rec Dept	5496	Jul-1994	0 (0)
White Rock Lake	Trinity	Dallas	08-2461	Apr-1914 Aug-1982	7.8 (8,703)

This Page Intentionally Left Blank

Appendix H. Conservation Pool Capacities and Dead Pool Storages Used for Model Simulations

Table H-1. Lake Grapevine Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
475.0	0	0	475.0	0	0
480.0	297	463	480.0	0	0
485.0	297	463	485.0	0	0
490.0	625	2,793	490.0	217	378
495.0	1,209	7,151	495.0	802	2,698
500.0	1,945	15,022	500.0	1,537	8,532
500.5[2]	2,001	16,009	500.5[2]	1,594	9,316
505.0	2,471	26,024	505.0	2,064	17,498
510.0	3,313	40,412	510.0	2,906	29,849
515.0	3,899	58,456	515.0	3,491	45,855
520.0	4,541	79,673	520.0	4,134	65,036
525.0	5,140	103,796	525.0	4,733	87,121
530.0	5,778	131,076	530.0	5,371	112,364
535.0[3]	6,742	161,919	535.0[3]	6,335	141,170

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 415 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-2. Lake Ray Roberts Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
550.0	0	0	550.0	0	0
551.0[2]	22	35	551.0[2]	0	0
560.0	727	2,861	560.0	482	1,081
570.0	2,016	16,102	570.0	1,771	11,831
580.0	4,226	46,795	580.0	3,981	40,054
590.0	6,851	102,472	590.0	6,606	93,269
600.0	9,836	184,487	600.0	9,591	172,826
610.0	14,473	305,111	610.0	14,228	290,991
620.0	20,062	476,716	620.0	19,817	460,138
630.0	26,765	711,014	630.0	26,520	691,979
632.5[3]	28,543	780,138	632.5[3]	28,298	760,489

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 393 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-3. Lake Lewisville Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			***2080 Sediment Conditions***		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
460.0	0	0	460.0	0	0
465.0	47	36	465.0	0	0
470.0	708	1,370	470.0	213	107
475.0	2,741	10,568	475.0	2,246	6,830
480.0	4,001	27,330	480.0	3,506	21,118
481.0[2]	4,215	31,438	481.0[2]	3,720	24,731
485.0	5,419	50,619	485.0	4,924	41,932
490.0	7,392	82,822	490.0	6,897	71,660
495.0	9,400	124,414	495.0	8,905	110,778
500.0	11,612	176,775	500.0	11,117	160,664
505.0	13,952	240,399	505.0	13,457	221,814
510.0	17,543	318,783	510.0	17,048	297,723
515.0	21,610	415,914	515.0	21,115	392,379
520.0	25,561	534,424	520.0	25,066	508,415
522.0[3]	26,980	586,841	522.0[3]	26,485	559,842

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 540 acft/yr. It should be noted that the US Army Corps of Engineers conducted a sediment survey of Lake Lewisville in June 2021 and released the final report in July 2024. Results of the June 2021 sediment survey were not available in time for inclusion in the 2024 LRWSP evaluation. However, projected sediment rates from the recent survey (349 ac-ft/yr) are less than those assumed in the development of the RWP 2030 and 2080 elevation-area-capacity relationships (540 ac-ft/yr); therefore, the relationships used in the 2024 LRWSP evaluation are more conservative for estimating yields from Lake Lewisville.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-4. Lake Ray Hubbard Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
390.0	0	0	390.0	0	0
396.0	1,307	1,964	396.0	441	221
400.0[2]	2,511	9,618	400.0[2]	1,645	4,411
405.0	5,680	29,943	405.0	4,814	20,406
410.0	8,146	65,087	410.0	7,280	51,221
415.0	10,465	111,632	415.0	9,599	93,436
420.0	12,839	169,782	420.0	11,973	147,255
425.0	15,054	239,566	425.0	14,188	212,709
430.0	18,188	322,566	430.0	17,322	291,380
435.0	20,194	418,906	435.0	19,328	383,390
435.5[3]	20,703	429,130	435.5[3]	19,837	393,181

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 719 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-5. Lake Tawakoni Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			***2080 Sediment Conditions***		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
385.0	0	0	385	0	0
390.0	2,327	4,705	390	1,017	846
391.0[2]	2,925	7,320	391.0[2]	1,614	2,151
400.0	7,897	56,213	400	6,586	39,248
410.0	13,988	167,459	410	12,677	137,388
420.0	21,211	343,237	420	19,901	300,059
430.0	29,917	594,902	430	28,606	538,617
437.5[3]	36,815	844,627	437.5[3]	35,504	778,513

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 1,322 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-6. Lake Fork Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
345.0	0	0	345.0	0	0
350.0	951	1,883	350.0	0	0
355.0	2,178	9,770	355.0	959	1,928
360.0[2]	3,690	23,988	360.0[2]	2,471	10,051
365.0	5,539	47,128	365.0	4,320	27,095
370.0	7,474	79,477	370.0	6,255	53,350
375.0	9,685	122,383	375.0	8,466	90,160
380.0	12,240	177,121	380.0	11,021	138,803
385.0	14,913	244,960	385.0	13,694	200,547
390.0	17,816	326,708	390.0	16,597	276,200
395.0	20,921	423,562	395.0	19,702	366,958
400.0	23,710	535,361	400.0	22,491	472,662
403.0[3]	26,436	609,572	403.0[3]	25,217	543,216

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region D Water Plan (and adopted by Region C) and annual sedimentation rate of 1,327 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-7. Joe Pool Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
450.0	0	0	450.0	0	0
452.0	10	3	452.0	0	0
455.0	37	79	455.0	0	0
460.0	71	349	460.0	0	0
465.0	114	816	465.0	0	0
470.0	229	1,597	470.0	23	8
475.0	439	3,168	475.0	233	547
480.0	908	6,511	480.0	703	2,860
485.0	1,326	12,047	485.0	1,120	7,365
486.0[2]	1,470	13,444	486.0[2]	1,264	8,556
490.0	1,895	20,236	490.0	1,689	14,525
495.0	2,481	31,125	495.0	2,275	24,384
500.0	3,138	45,059	500.0	2,932	37,289
505.0	3,855	62,556	505.0	3,649	53,756
510.0	4,503	83,404	510.0	4,297	73,575
515.0	5,276	107,876	515.0	5,070	97,017
520.0	6,146	136,332	520.0	5,940	124,444
522.0[3]	6,654	149,112	522.0[3]	6,448	136,812

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 246 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-8. Lavon Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			2080 Sediment Conditions		
Elevation (ft-msl)	Area (acres)	Capacity (acft)	Elevation (ft-msl)	Area (acres)	Capacity (acft)
450.0	0	0	450.0	0	0
453.0[2]	1,444	2,484	453.0[2]	738	753
455.0	2,010	5,918	455.0	1,305	2,775
460.0	4,042	21,177	460.0	3,336	14,505
465.0	6,531	47,359	465.0	5,825	37,158
470.0	8,883	85,781	470.0	8,177	72,051
480.0	13,898	198,695	480.0	13,192	177,906
485.0	16,921	275,325	485.0	16,215	251,006
490.0	19,685	367,377	490.0	18,979	339,528
492.0[3]	20,477	407,522	492.0[3]	19,771	378,262

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region C Water Plan and annual sedimentation rate of 585 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-9. Lake Palestine Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			***2080 Sediment Conditions***		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
292.3	0	0	292.3	0	0
295.0	0	0	295.0	0	0
300.0	0	0	300.0	0	0
305.0	0	0	305.0	0	0
309.5[2]	393	812	309.5[2]	0	0
310.0	465	1,026	310.0	0	0
315.0	2,111	6,898	315.0	1,232	2,565
320.0	4,333	22,708	320.0	3,132	13,194
325.0	7,484	52,101	325.0	5,954	35,774
330.0	11,003	97,979	330.0	9,166	73,248
335.0	14,872	163,110	335.0	12,787	128,581
340.0	18,235	246,301	340.0	16,023	201,032
345.0[3]	22,397	347,158	345.0[3]	20,325	291,182

[1]2030 Sediment conditions based on 2030 elevation-area-capacity relationships used in the 2026 Region I Water Plan (also adopted by Region C). 2080 Sediment conditions estimated based on 2080 elevation-area-capacity relationships calculated by HDR using the 2012 TWDB Rating Curve and annual sedimentation rate of 1,119.2 acft/yr.

[2]Top of Dead Pool Storage

[3]Top of Conservation Pool

Table H-10. Chapman Elevation-Area-Capacity Relationships for 2030 and 2080 Sediment Conditions[1]

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	*Area (acres)*	*Capacity (acft)*	*Elevation (ft-msl)*	*Area (acres)*	*Capacity (acft)*
397.0	0	0	397.0	0	0
398.0	163	410	398.0	0	0
399.0	181	581	399.0	0	0
400.0	202	773	400.0	0	0
401.0	238	992	401.0	0	0
402.0	330	1,267	402.0	0	0
403.0	549	1,706	403.0	0	0
404.0	761	2,370	404.0	0	0
405.0	972	3,231	405.0	0	0
406.0	1,209	4,319	406.0	0	0
407.0	1,518	5,675	407.0	0	0
408.0	1,855	7,365	408.0	0	0
409.0	2,196	9,388	409.0	69	345
410.0	2,511	11,744	410.0	377	570
411.0	2,929	14,451	411.0	804	1,148
412.0	3,348	17,602	412.0	1,248	2,187
413.0	3,688	21,124	413.0	1,627	3,628
414.0	4,019	24,979	414.0	2,009	5,447
415.0	4,389	29,177	415.0	2,443	7,668
416.0[2]	4,727	33,742	416.0[2]	2,855	10,323
417.0	5,075	38,646	417.0	3,285	13,396
418.0	5,373	43,874	418.0	3,674	16,879
419.0	5,689	49,403	419.0	4,088	20,759
420.0	5,999	55,250	420.0	4,500	25,055
421.0	6,317	61,405	421.0	4,925	29,764
422.0	6,671	67,897	422.0	5,389	34,919
423.0	7,076	74,765	423.0	5,905	40,559
424.0	7,579	82,090	424.0	6,519	46,770
425.0	8,122	89,926	425.0	7,174	53,601
426.0	8,751	98,364	426.0	7,911	61,145
427.0	9,353	107,412	427.0	8,620	69,407
428.0	10,128	117,138	428.0	9,497	78,452
429.0	10,934	127,681	429.0	10,401	88,413
430.0	11,592	138,948	430.0	11,150	99,192
431.0	12,220	150,856	431.0	11,863	110,700
432.0	12,910	163,414	432.0	12,629	122,939

2030 Sediment Conditions			*2080 Sediment Conditions*		
Elevation (ft-msl)	***Area (acres)***	***Capacity (acft)***	***Elevation (ft-msl)***	***Area (acres)***	***Capacity (acft)***
433.0	13,585	176,662	433.0	13,373	135,940
434.0	14,251	190,596	434.0	14,098	149,691
435.0	14,928	205,184	435.0	14,825	164,152
436.0	15,656	220,481	436.0	15,593	179,365
437.0	16,268	236,454	437.0	16,235	195,290
438.0	16,845	253,011	438.0	16,832	211,824
439.0	17,423	270,145	439.0	17,420	228,950
440.0[3]	17,998	287,856	440.0[3]	17,998	246,659

[1]Estimated on basis of 2030 and 2080 elevation-area-capacity relationships used in the 2026 Region D Water Plan (and adopted by Region C) and annual sedimentation rate of 830 acft/yr.

[2]Top of Dead Pool Storage at 415.5 ft-msl

[3]Top of Conservation Pool

This Page Intentionally Left Blank

Appendix I. Technical Memorandum

Draft Technical Memorandum

Date:	Tuesday, October 01, 2024
Project:	2024 Dallas Long Range Water Supply Plan
To:	Denis Qualls, PE – DWU Chang Lee, PE - DWU
From:	Zach Stein, PE – HDR Caroline Nellis - HDR

1 Introduction

As part of the 2024 Dallas Long Range Water Supply Plan (LRWSP), the reliability of Dallas' existing reservoir supply sources must be determined for comparison to projected water user demands to determine future water supply needs. A primary risk to the reliability of these supply sources is the potential impacts of climate change. HDR completed a literature review, performed a cursory hydrologic trends analysis and reviewed Global Climate Model (GCM) projections to develop assumptions for future climate conditions to be applied in the water availability modeling and determination of Dallas' reservoir yields. This technical memorandum summarizes findings from the analysis and provides the assumptions used in the water availability modeling.

2 Literature Review

A literature review was completed to identify previous studies related to climate change and projected changes in hydrology which may impact or benefit Dallas' supply sources. While many sources were reviewed, the 2024 updated report from the Office of the Texas State Climatologist titled, "*Assessment of the Historic and Future Trends of Extreme Weather in Texas, 1900-2036"* [1]**,** provided the most comprehensive and recent review of historical hydrological trends and projected future trends in Texas and the Dallas area. Findings from this report, along with GCM projections and historical trends identified in the historical hydrology of Dallas' supply reservoirs, provide the basis for climate change assumptions used the 2024 LRWSP. Additional studies included in the literature review are listed at the end of this document.

The State Climatologist report shows that Texas' climate has already changed in ways that leave the state more vulnerable to extreme weather. The study analyzed a variety of past and future meteorological trends, including average temperatures, extreme temperatures, precipitation, extreme rainfall, drought, river flooding, urban flooding, winter precipitation, severe thunderstorms, hurricanes and coastal erosion, and wildfires. The following excerpts summarize key findings from the report which support assumptions used in the 2024 LRWSP.

2.1 Temperature and Associated Evaporation

"Historical data and climate models lead to similar conclusions. If recent trends continue, as expected, a middle-of-the-road estimate of the overall rate of temperature increase in Texas would be about 0.6 °F

per decade. This means that average Texas temperatures in 2036 should be expected to be about 1.8 °F warmer than the 1991-2020 average and 3.0 °F warmer than the 1950-1999 average. This would make a typical year around 2036 warmer than all but the absolute warmest year experienced in Texas during 1895-2020[1]*. Even a very conservative extrapolation, based on the average of the 1950-2020 and 1975-2020 trends, would make a typical year around 2036 warmer than all but the five warmest years on record so far."*

"Increased carbon dioxide does not reduce the temperature effect of evaporation from lakes and reservoirs or from bare soil. Historically, there has been an increase in the evaporative capacity of the atmosphere across most of Texas, especially in West Texas and the Panhandle, which is expected to continue due to robust projections of rising temperatures [2]*. A continuation of the observed trend would lead to a roughly 7% increase in expected summertime evaporative losses from reservoirs in 2036 compared to 2000-2018, much larger than historic increases in precipitation* [3].

2.2 Rainfall

"The long-term trend of precipitation in Texas has been positive. Over the past century, parts of central and eastern Texas have experienced precipitation increases of 15% or more, while in much of the western part of the state the long-term trend is flat or even slightly downward. The tendency for increasing precipitation in Texas is not consistent with the majority of global climate models, with the average simulated trend being -2.6% per century[2]*. Models and observations both tend to feature more positive (or less negative) trends toward northeastern Texas than toward southwestern Texas* [4].*"*

"The climate model projections provide weak evidence for a precipitation decline. Unlike earlier model projections, the latest CMIP6 projections do not have precipitation in summertime declining more than precipitation in other seasons[3]*. As noted earlier, computer model projections of overall rainfall amounts in Texas are somewhat inconsistent, but in general they show an overall leveling off or slight decrease of precipitation amounts* [5].*"*

2.3 Droughts

"Because of all the factors at play, it is impossible to make quantitative statewide projections of drought trends. The majority of factors point toward increased drought severity, including more erratic runoff into reservoirs. Nonetheless, any such underlying trend may be dwarfed during the next couple of decades by the impact of multidecadal variability, which historical records show is large for Texas. Also, as indicated by paleoclimate records, worse droughts have occurred in Texas than the climate data record alone would indicate. Future rainfall deficits comparable to those earlier in the 20th century will have greater impacts due to higher temperatures [6].*"*

---

[1] 1900-1999 average: 64.6 °F. 2000-2018 average: 66.0 °F. 2036 projection: 67.6 °F. Warmest year on record: 2012 (67.8 °F).

[2] Precipitation from single ensemble members from the Historical+RCP4.5 CMIP5 runs were averaged over the box 25°N-37.5°N, 95°W-105°W and downloaded from the KNMI Climate Explorer. The models were: ACCESS1-0 ACCESS1-3 bcc-csm1-1 bcc-csm1-1-m BNU-ESM CanESM2 CCSM4 CESM1-BGC CESM1-CAM5 CMCC-CM CMCC-CMS CNRM-CM5 CSIRO-Mk3-6-0 EC-EARTH FGOALS-g2 FIO-ESM GFDL-CM3 GFDL-ESM2G GFDL-ESM2M GISS-E2-H GISS-E2-H GISS-E2-H GISS-E2-H-CC GISS-E2-R GISS-E2-R GISS-E2-R GISS-E2-R-CC HadGEM2-AO HadGEM2-CC HadGEM2-ES inmcm4 IPSL-CM5A-LR IPSL-CM5A-MR IPSL-CM5B-LR MIROC5 MIROC-ESM MIROC-ESM-CHEM MPI-ESM-LR MPI-ESM-MR MRI-CGCM3 NorESM1-M NorESM1-ME.

[3] Bukovsky at al. (2017) argued for a plausible tendency for less precipitation in Texas in the summertime in CMIP5 models, but CMIP6 model simulations do not have a clear summertime drying signal in Texas.

3 Historical Hydrologic Trends for Dallas Reservoirs

Historical hydrologic trends, particularly climate trends within the last 30 years, are extremely important to understanding the current climate direction, and are a key component of understanding the magnitude of future projected change. These trends, when extrapolated, provide a baseline for anticipated future climate change trends despite short-term variability.

Historical temperature data was obtained from the National Weather Service for the Dallas/Ft. Worth area and historical hydrologic data was extracted from the Dallas RiverWare model for the 1907-2020 period of record and plotted to identify any observed trends in the data. **Figures 1** through **4** provide annual timeseries of temperature, gross evaporation, rainfall, and inflows for Lakes Grapevine, Ray Hubbard and Fork which are geographically located in the western, central and eastern portions of Dallas' supply system. Each figure includes long-term linear trendlines or averages and 10- or 20-year moving averages to assist in identifying trends in the data.

The following general conclusions can be made from historical data:

- Temperatures have increased by approximately 2°F since 2020 compared to the historical long-term average for 1900-1999. This increase is consistent with the 2°F increase assumed in the 2014 LRWSP for 2020 model conditions.
- Long-term trends show increasing streamflows for all three reservoirs sites. However, a significant portion of the more recent increases in the LRH inflows over the last 30-years are likely attributed to the significant increase in impervious cover of the contributing watershed. This change in land cover is also present in the Lake Grapevine watershed to a lesser extent.
- While inflows to Lake Fork show a long-term increasing trend, the recent period from 2003-2017 shows a prolonged period with a higher frequency of years with below average inflows and a decrease in the 20-year moving average. This trend may be an indicator of the increased likelihood of longer drought periods resulting from climate change.
- All three reservoirs shown in the figures (and all reservoirs in the model) have long-term increasing trends in gross evaporation rates with all three reservoirs having annual evaporation rates in some years since 2000 that are near or exceed those experienced during the 1950s drought.
- All three reservoirs shown in the figures (and all reservoirs in the model) have long-term increasing trends in rainfall. During the recent 20-year period, there also appears to be greater variability in rainfall which may be an indicator of the increased likelihood of more intense rainfall events and dry years resulting from climate change.

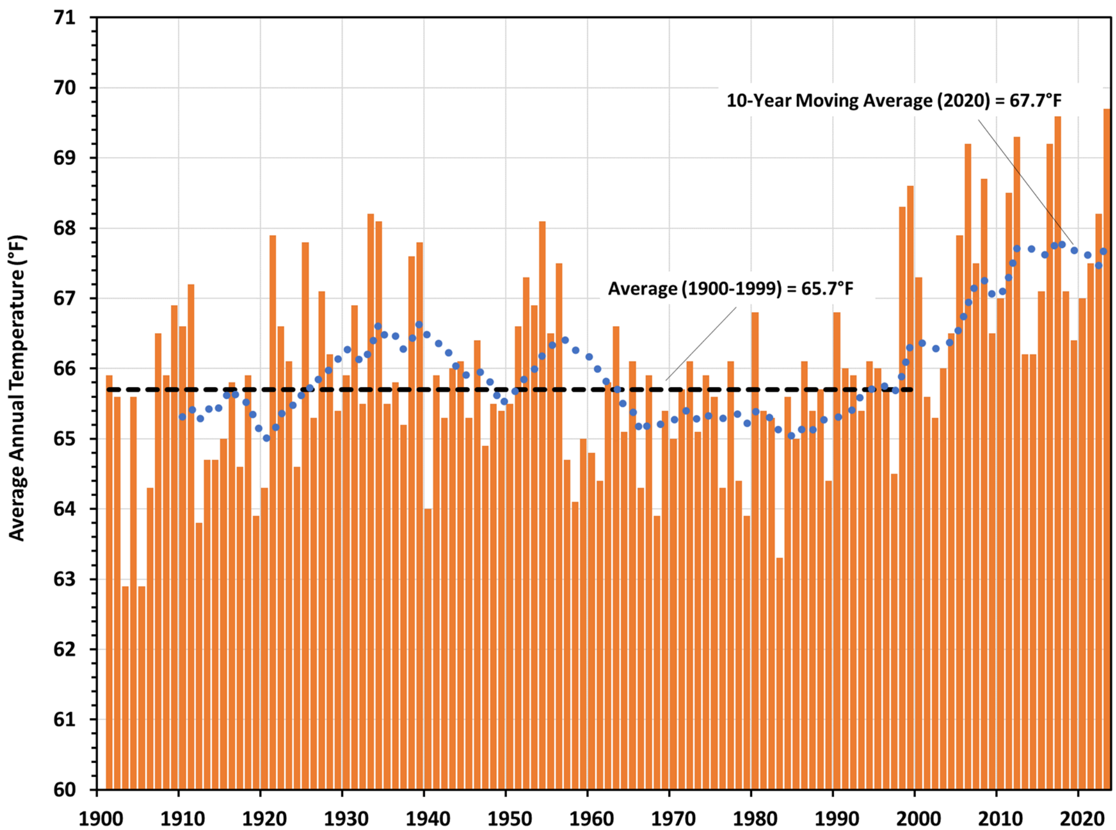


Figure 1. Historical Average Annual Temperature for Dallas-Ft. Worth Area [7]

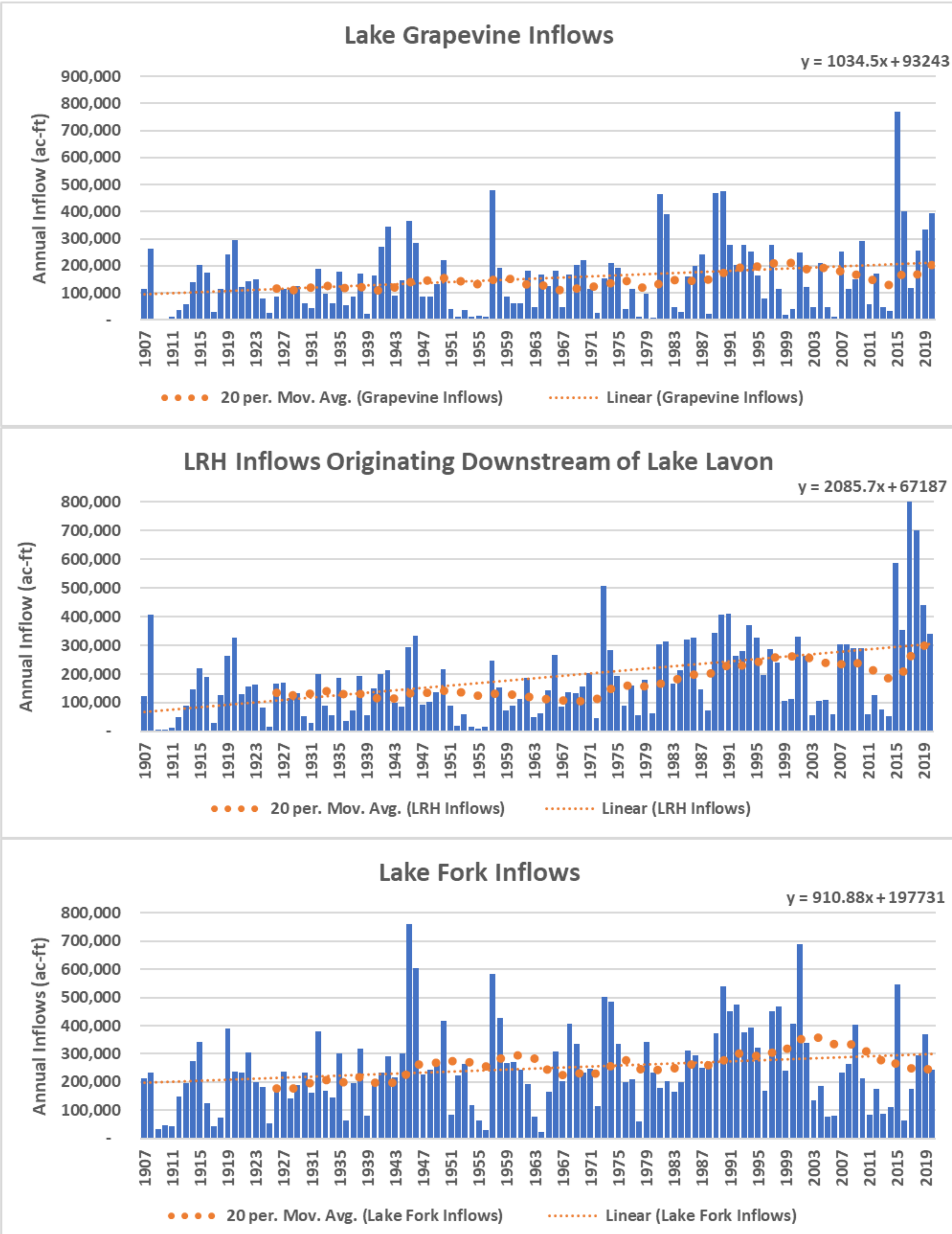


Figure 2. Historical Annual Inflows for Selected Dallas Reservoirs

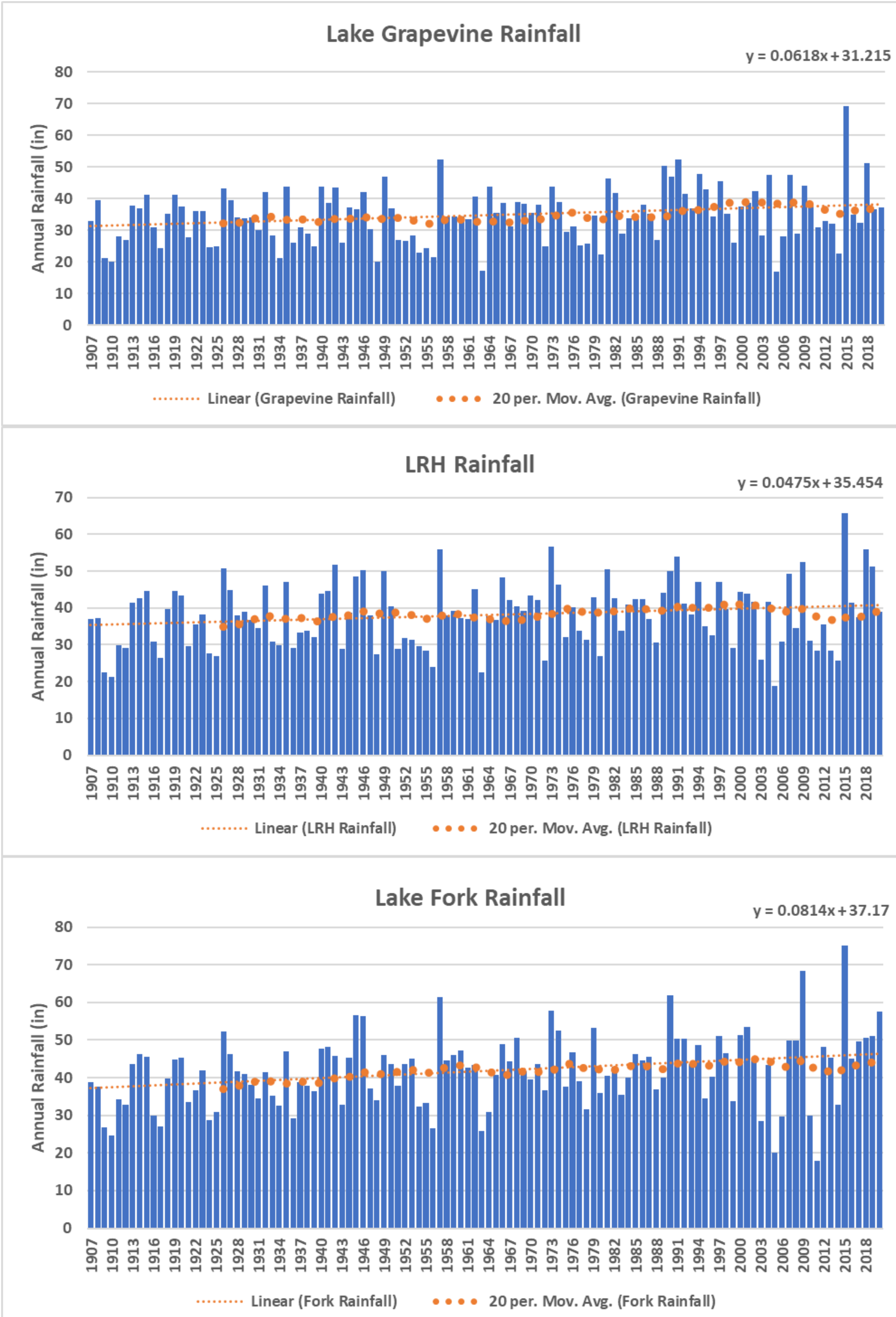


Figure 3. Historical Annual Rainfall for Selected Dallas Reservoirs

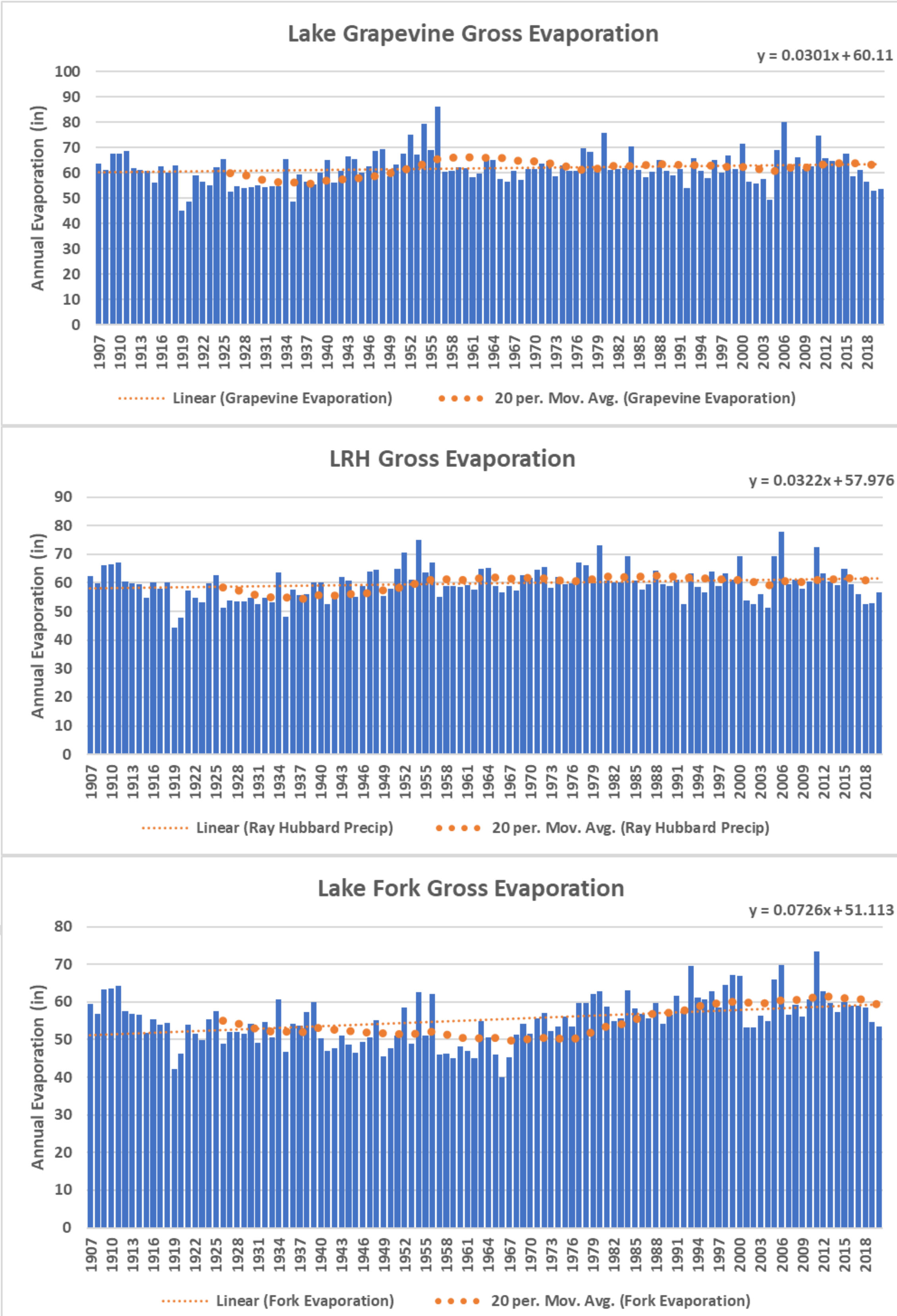


Figure 4. Historical Annual Gross Evaporation for Selected Dallas Reservoirs

4 Climate Model Projections

GCMs provide long-term projections of temperature and rainfall at a course-resolution. In order to apply projections from these models to the northeast Texas area which contain Dallas' supply reservoirs, GCM data must be downscaled. Downscaled data was obtained from the U.S. Climate Resilience Toolkit's Climate Explorer tool [8] and used to inform water availability modeling assumptions in the LRWSP.

The U.S. Climate Resilience Toolkit's Climate Explorer tool downscaled data is based on statistical downscaling of temperature and precipitation projections from the Coupled Model Intercomparison Project Phase 5 [9] (CMIP5) using Localized Constructed Analogs (LOCA). LOCA data for historical and future periods are freely available for the contiguous United States, Southern Canada, and Northern Mexico [10]. LOCA was developed for the California Climate Change Assessment, the Southwest Climate Science Center and other U.S. planning efforts, including the Fourth National Climate Assessment of the U.S. Global Change Research Program.

LOCA downscales (or localizes) temperature or precipitation simulated by a coarse-resolution GCM by looking for observed days that match the model day both regionally and locally around each grid cell being downscaled. The matching observed days identified at each grid cell are then joined across the domain like a jigsaw puzzle [11]. The result is a final downscaled field at the same spatial resolution as the observations. The LOCA dataset offers projections for two plausible futures: a higher greenhouse gas emissions future (RCP8.5) and a lower emissions future (RCP4.5)

For counties in the contiguous United States, 32 of the global climate models that participated in the (CMIP5) were used to produce the range of projections. GCMs represented in LOCA data are: ACCESS1-0, ACCESS1-3, CCSM4, CESM1-BGC, CESM1-CAM5, CMCC-CM, CMCC-CMS, CNRM-CM5, CSIRO-Mk3-6-0, CanESM2,, EC-EARTH, FGOALS-g2, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, GISS-E2-H, GISS-E2-R, HadGEM2-AO, HadGEM2-CC, HadGEM2-ES, IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, MPI-ESM-LR, MPI-ESM-MR, MRI-CGCM3, NorESM1-M, Bcc-csm1-1, Bcc-csm1-1-m, and inmcm4.

The models are weighted using an approach that considers skill in climatological performance of models over North America and interdependency of models arising from common parameterizations. For more information on weights assigned to each model, see Climate Science Special Report, Fourth National Climate Assessment (NCA4), Volume 1 [12].

The figures obtained from the U.S. Climate Resilience Toolkit's Climate Explorer tool include a weighted average mean of all model results downscaled to the Dallas County area for the higher and lower greenhouse gas emissions futures. The figures also provide the largest and smallest value of the model results for each parameter. These projections are compared against the observed average (horizontal gray line) from 1961-1990 in the figures. The gray band provides the range of values modeled (hindcast) for 1950-2005.

4.1 Projected Rainfall

Rainfall in northeast Texas has become more variable in the last 20 years as shown in **Figure 3** by the increasing number of years with extreme rainfall along with the increase in years with below average rainfall. However, the downscaled GCMs do not generally predict long-term average annual rainfall to significantly change in the Dallas area (

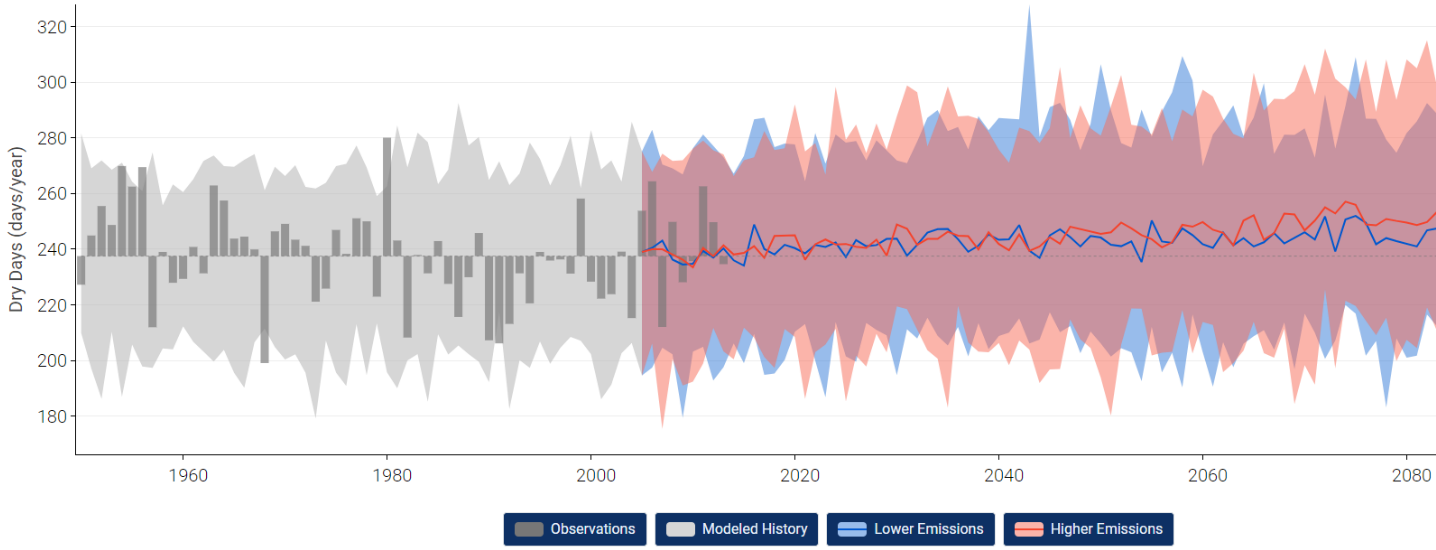


Figure 5). However, the model extremes also provided in the figure show the increasing uncertainty in the various models and the increase in the models predicting both extreme wet and dry years compared to the observed data.

Error! Reference source not found. provides the projections for dry days per year for each emissions scenario. The projections indicate an increase of about 10 dry days per year by 2080 with the range of model extremes increasing similar to the range of extremes for the annual rainfall projections.

4.2 Projected Temperature

Projected increases in daily maximum and minimum temperatures are provided in **Figure 6**. Both emissions scenarios project a 3°F increase in 2030 of average daily maximum and minimum temperatures. For the higher emissions scenario, average maximum and minimum daily temperatures are projected to increase by approximately 8°F in 2080 from the observed average. The lower emission scenario projects an increase of approximately 5°F in 2080 from the observed average.

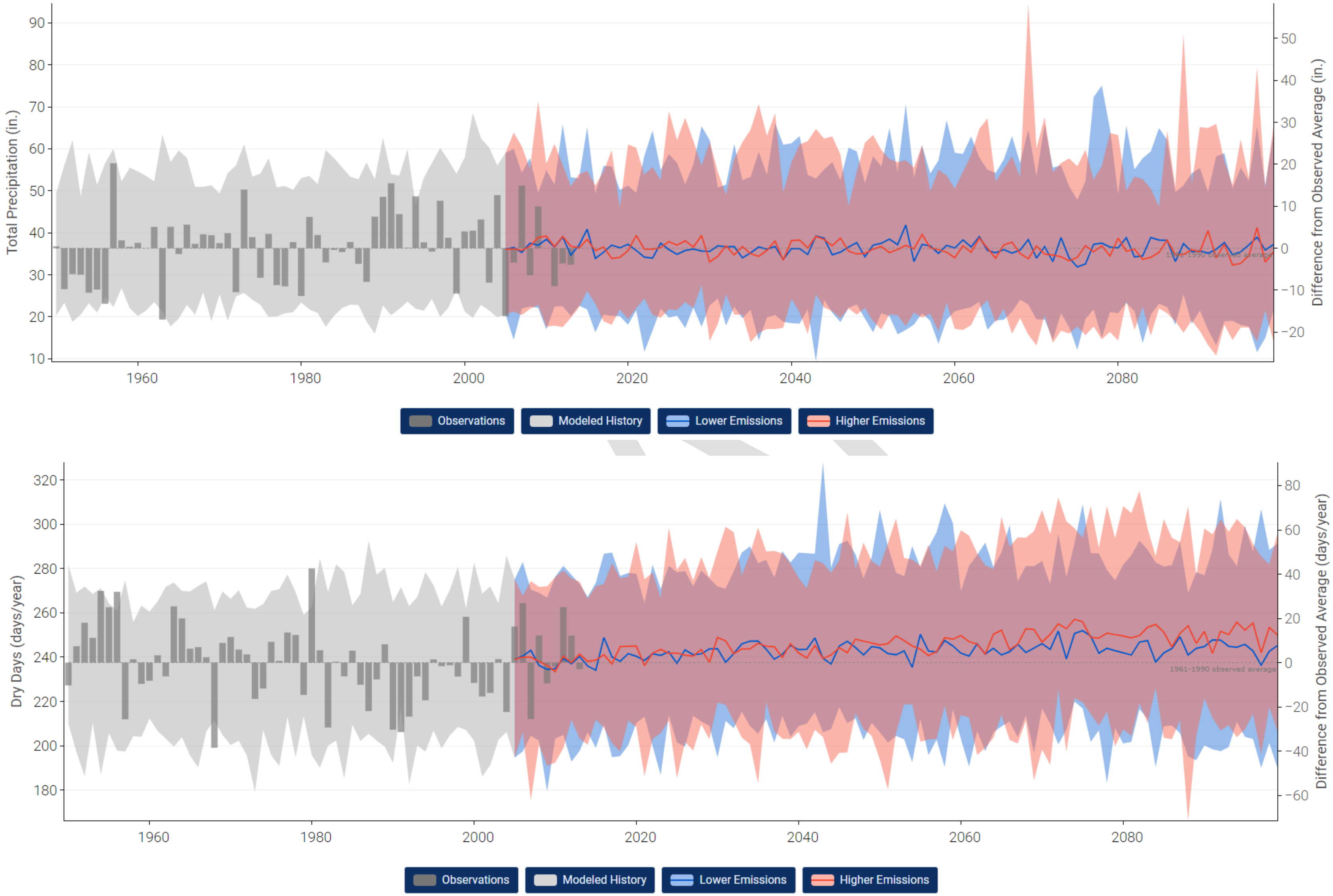
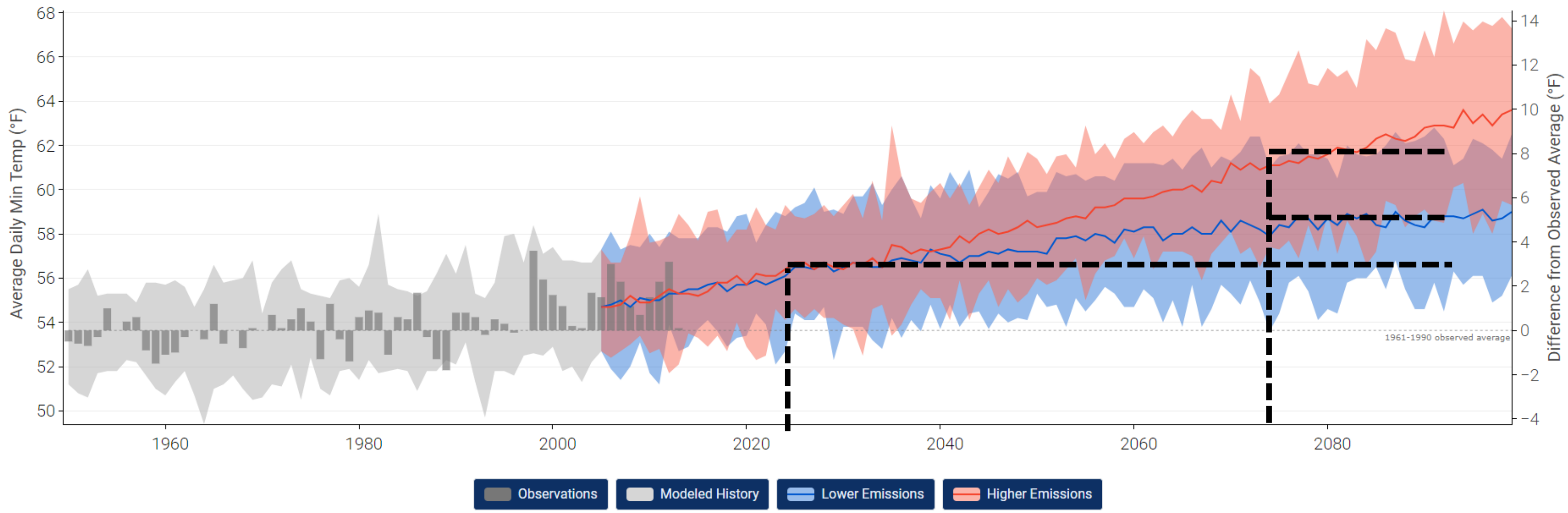


Figure 5. Projected Annual Rainfall and Dry Days per Year for Dallas County



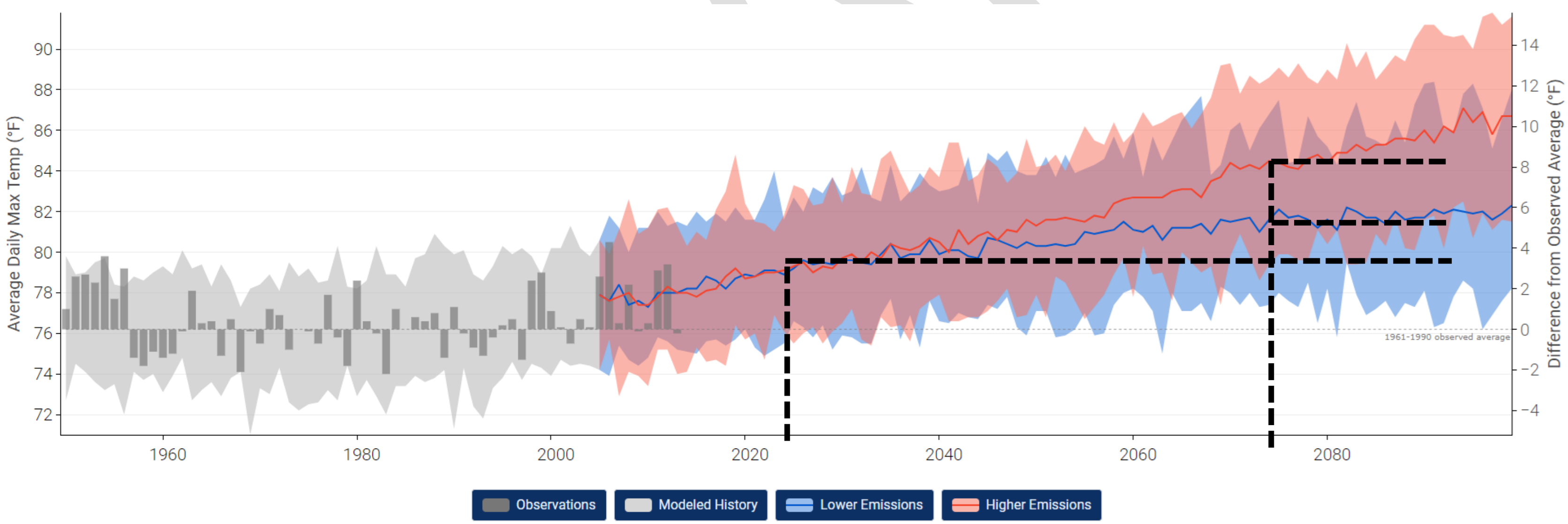


Figure 6. Projected Average Daily Minimum and Maximum Temperatures for Dallas County

5 Water Availability Modeling Assumptions for Climate Change

Dallas' supply reservoirs are susceptible to changes in climate through increased evaporation from projected temperature increases and from projected changes in the intensity, duration and frequency of rainfall events which could lead to changes in inflows and more severe droughts than those historically occurring in northeast Texas. The following sections provide the approach and assumptions used in the water availability modeling to estimate impacts to the reliability of supply from Dallas' reservoirs which are based on the findings from the literature review and GCM projections.

5.1 Adjustments to Evaporation for Projected Temperature Changes

The 2014 LRWSP assumed a projected average temperature increase of 2°F in 2020 and 7°F in 2070 from the historical average for 1954-1996. This projected temperature increase was translated to an increase in evaporation using non-linear relationships between monthly averages of daily high temperatures and monthly gross evaporation estimates from the Texas Water Development Board for Quadrangle 407 (**Figure 7**). For more information on the development of the relationships, refer to the 2010 HDR IPL Technical Memo No. 5. These relationships are still considered valid as they were developed using data from the 1954-1996 period and prior to 2000 when impacts from climate change are generally considered to have begun to occur.

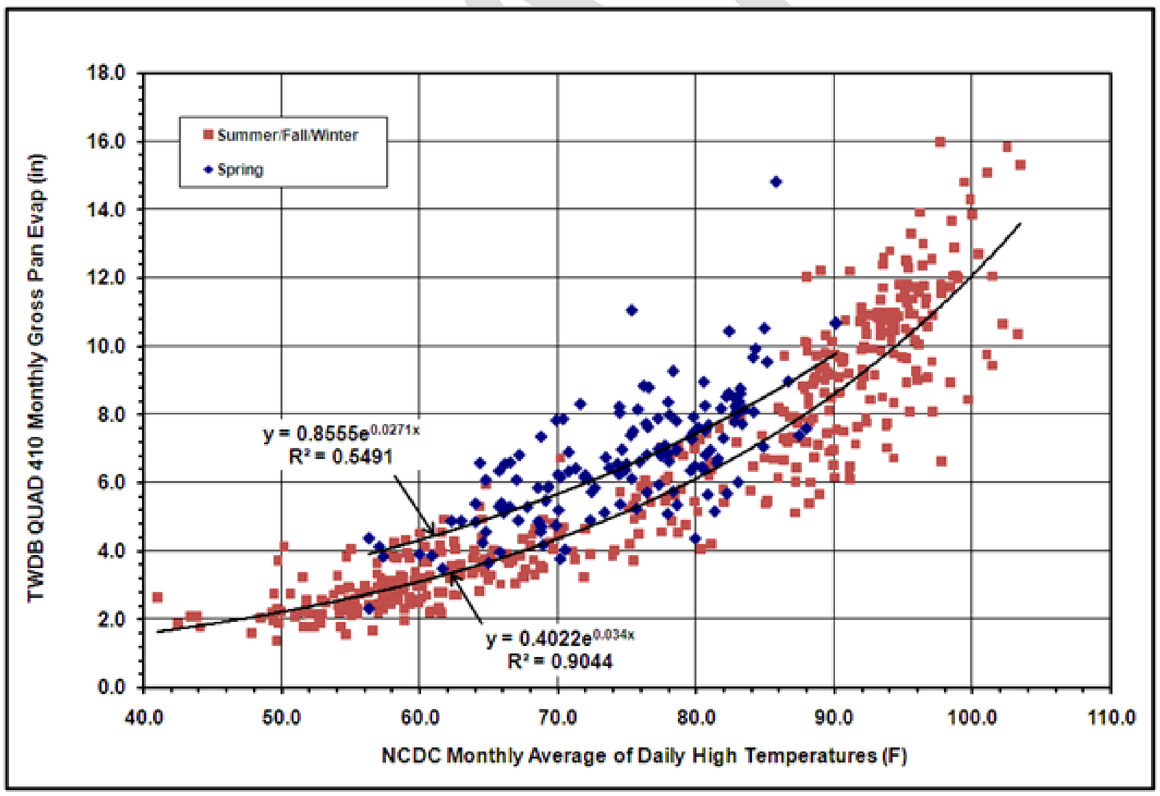


Figure 7. ***Comparison of regression equations for spring months (March, April and May) and all other months*** **(IPL Technical Memo No. 5, 2010).**

The derived relationships were applied to historical gross evaporation estimates included in the Dallas RiverWare model for each reservoir to calculate a historical average monthly high temperature throughout the model period of record (1907-2020). This calculated temperature was then increased by the assumed temperature increase from climate change in 2030 and 2080. The evaporation-temperature relationship was applied again to estimate the resulting gross evaporation from the adjusted historical temperature.

Table 1 provides the assumed projected increases in temperature for current (2030) and future (2080) conditions and are conservatively based on the higher emissions scenario GCM projections shown in **Figure 6**. These projected temperature increases are consistent with the projections assumed in the 2014 LRWSP (1°F per decade).

Table 1. Assumed Projected Average Daily Maximum Temperature Increase from Historical [a]

Decade	Projected Average Temperature Increase from Historical (°F)
2030	3
2080	8

[a] Historical period is considered to be 1961-1990 and prior to temperature increases from climate change.

Based on the recent upward trend in temperature as shown in **Figure 1**, it is assumed that increases in temperature from climate change began around 2000; therefore, historical evaporation included in the model period of record for 2000-2020 already include increased evaporation from increased temperature. In order to properly account for this temperature increase, historical evaporation data from 2000-2009 is assumed to already reflect a temperature increase of 1°F and evaporation data for 2010-2020 is assumed to already reflect a temperature increase of 2°F from historical temperatures. **Table 2** provides the resulting temperature adjustments applied to the model period of record to estimate evaporative losses in 2030 and 2080 using adjusted historical evaporation.

Table 2. Temperature adjustments by decade used for future lake evaporation estimates. All values are rounded to the nearest degree (°F).

RiverWare Model Period	Climate Change Temperature Adjustment to Historical Evaporation for Current (2030) Conditions (°F)	Climate Change Temperature Adjustment to Historical Evaporation for Future (2080) Conditions (°F)
1907-1999	3	8
2000-2009	2	7
2010-2020	1	6

Figure 8 provides the adjusted historical evaporation depths for current and future conditions for Lake Grapevine, LRH, and Lake Fork. These adjustments to evaporation were completed for all of Dallas' supply reservoirs to estimate firm yields as part of the 2024 LRWSP existing supplies evaluation.

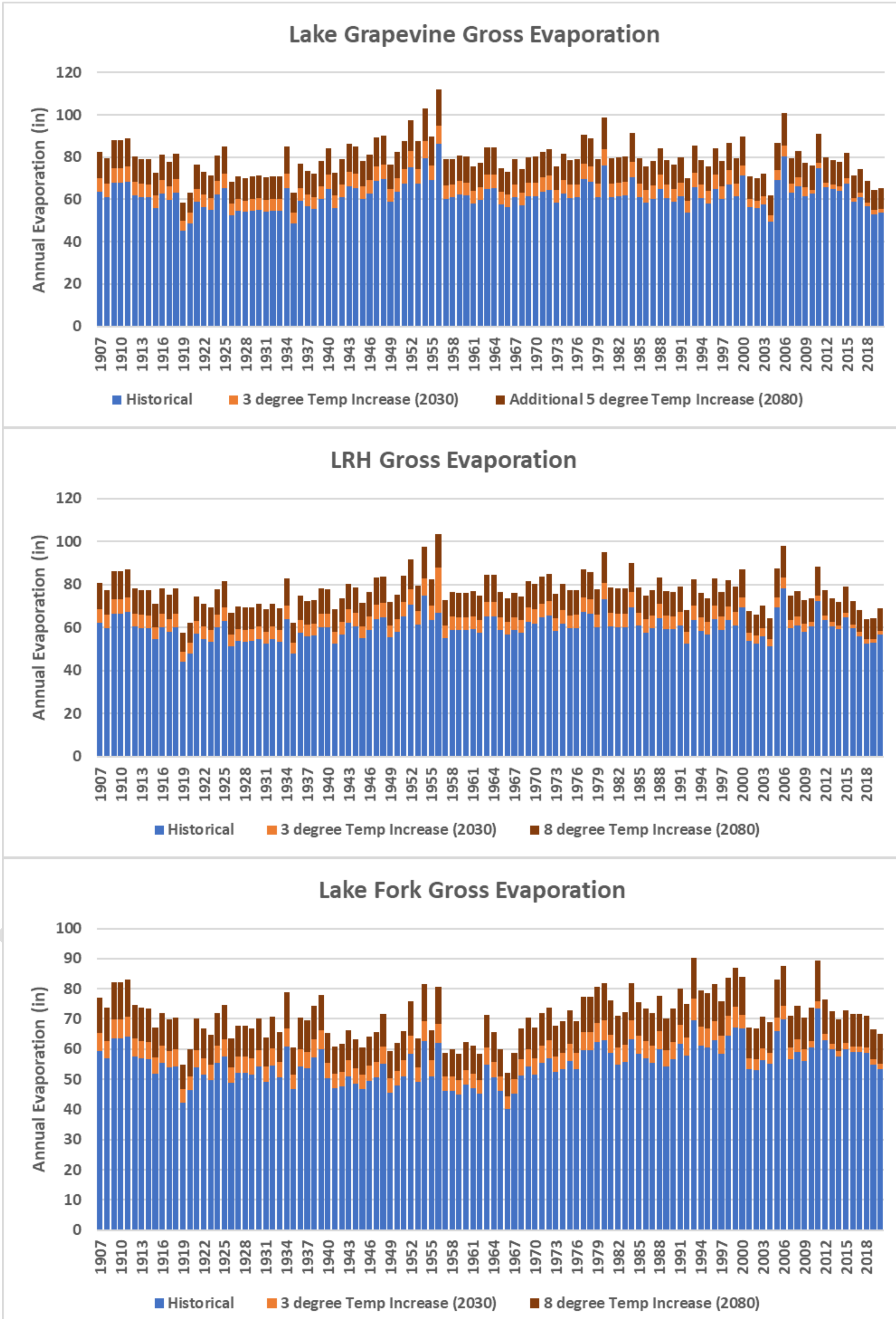


Figure 8. Adjusted Gross Evaporation for Projected Temperature Increase

5.2 Adjustments to Inflows and Droughts for Climate Change

Droughts and flood events are expected to increase in intensity, duration and frequency. However, current climate models have a high level of uncertainty in the quantification of changes to the characteristics of these extreme events, which present challenges in accurately quantifying their current and future impacts, or potential benefits, to the reliability of Dallas' supply sources. As shown in **Figure 5**, downscaled GCM projections suggest that average rainfall will not significantly change but the number of dry days and the variability and of rainfall from year to year will increase.

Translating changes in intensity, duration and frequency of storm events to changes in reservoir inflows also presents many challenges as this relationship is complex, non-linear, and varies by reservoirs depending on watershed characteristics. Based on the GCM projections, climate change will increase intensity and duration of storm events, thus likely creating additional streamflows for a given storm event. However, due to the inherent uncertainty in the models, it is conservatively assumed that the predicted increase in intensity of storm events will not provide an increase in inflows compared to historical climate conditions prior to climate change.

While climate models project factors which will likely lead to more severe drought conditions, they do not provide enough resolution to quantify the increase in severity and frequency of such droughts. In order to account for the projected increase in drought intensity and duration, a synthetic drought period was created which extends the 1950s drought by an additional year. The 1950s drought generally lasted from 1950 to the spring of 1957 when widespread rainfall provided relief. To extend the drought by one year, instead of modeling the historical net evaporation, precipitation, and inflows in 1957 which led to recovery from the drought, a synthetic worst year was developed for 1957 which extended the 1950s drought another year.

The synthetic year (1957) of the drought was developed by repeating the most severe year on record of net evaporation and inflows across the 1907-2020 period of record for each reservoir. In addition to the worst year drought extension, climate change impacts to evaporation were accounted for by modeling a temperature increase of 3 degrees to adjust the net evaporation for simulation year 2030 and a temperature increase of 8 degrees to adjust the net evaporation for simulation year 2080. **Table 3** provides the most severe year for inflow and net evaporation which was repeated for 1957 in the model simulations.

Table 3. Most Severe Year of Inflows and Net Evaporation in Dallas RiverWare Model Period of Record

INFLOWS						
Reservoir	Grapevine	Ray Roberts	Lewisville	Hubbard	Tawakoni	Fork
Calendar Year	1909	1956	1909	1909	1909	1964
NET EVAPORATION						
Reservoir	Grapevine	Ray Roberts	Lewisville	Hubbard	Tawakoni	Fork
Calendar Year	1956	1956	1956	2005	2011	2011

6 Additional Literature Review

Texas State Climate Summary 2022 [13]
The Texas climate is characterized by hot summers and mild to cool winters. Three geographical features largely influence the state's varied climate: the Rocky Mountains block intrusions of moist Pacific air from the west and tend to channel arctic air masses southward during the winter; the relatively flat central North American continent allows easy north and south movement of air masses; and the Gulf of Mexico serves as the primary source of moisture, which is most readily available to the eastern part of the state. As a result of these factors, the state exhibits large east-west variations in precipitation and is subject to frequent and varied extreme events, including hurricanes, tornadoes, droughts, heat waves, cold waves, and extreme precipitation. Due to rapid population growth, especially in urban areas, increased demand for limited water supplies may increase Texas's vulnerability to naturally occurring droughts.

Water Shortage in Texas: Causes, Effects and Solutions [14]
Extreme weather events related to climate change are forcing governments around the world to adapt their infrastructure systems accordingly to new pressures. For the US state of Texas, its record-low temperatures in February 2021 revealed the fragility of its water plants, creating a snowball effect of power shortages, water system breakdowns, and widespread risks to health and food security. The livelihood of rural Texan communities highly depends on outdated and poorly maintained aquifers and last year's crisis was a wake-up call for both local and national governments to take immediate action and rethink the state's water systems. We explore what causes water shortage in Texas and how the state is dealing with this major crisis.

Texas' Future Depends on Extreme Weather Preparedness, New Studies Show [15]
Texas A&M report shows that Texas' climate has already changed in ways that leave the state more vulnerable to extreme weather. The study analyzed a variety of past and future meteorological trends, including average temperatures, extreme temperatures, precipitation, extreme rainfall, drought, river flooding, urban flooding, winter precipitation, severe thunderstorms, hurricanes and coastal erosion, and wildfires.

Fourth National Climate Assessment [16]
The impacts of climate change are already being felt in communities across the country. More frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage infrastructure, ecosystems, and social systems that provide essential benefits to communities. Future climate change is expected to further disrupt many areas of life, exacerbating existing challenges to prosperity posed by aging and deteriorating infrastructure, stressed ecosystems, and economic inequality.

What Climate Change Means for Texas [17]
Since the late 1700s, atmospheric carbon dioxide has increased by 40%, leading to a global temperature increase, increasingly acidic oceans, and sea rise. The sea level on the Texas coast is predicted to rise between 2 and 5 feet in the next century due to the combination of climate change and ground water pumping. Climate change is also predicted to increase severe storms, inland flooding, severity of wildfires, and water availability. In combination with intense natural disasters, increasing temperatures can negatively impact human health through the formation of ozone and occurrence of heat stroke and dehydration.

Climate change has sent temperatures soaring in Texas [18]
Climate change is being felt across Texas as atmospheric carbon dioxide levels peaked at 424 parts per million in May 2023. Since 1900, Texas has experienced a 3°F increase in average monthly temperature. However, the increase is not uniform across the state. Areas in west and southeast Texas are experiencing larger temperature increases than central regions. In many parts of Texas, the number of "record highs" in 2013-2022 increased significantly from "record highs" recorded prior to 2013. The number of record high temperatures has increased 510% since 1913, reflecting the severe heat waves and climate change experienced in Texas.

4 Environmental Issues in Texas in 2023 [19]
Within the past century, most of Texas has warmed at an average of almost 1.5F (0.8C), and summers are getting longer and hotter. The most recent and still ongoing heatwave that hit central US and Texas in late April 2022 has led to three-digit temperatures in the state's southern and mid-western band for several consecutive days and is spreading north through the Great Plains. According to the aforementioned report, the number of triple-digit days in a year will double by 2036 compared to the past 20 years and temperatures will be a full three degrees warmer than they were from 1950 to 1999.

7 References

[1] J. Nielsen-Gammon, S. Holman, A. Buley, S. Jorgensen, J. Escobedo, C. Ott, J. Dedrick and A. Van Fleet, "Assessment of Historic and Future Trends of Extreme Weather in Texas, 1900-2036," 2024. [Online]. Available: https://texas2036.org/wp-content/uploads/2023/06/2024_ClimateReport.pdf.

[2] R. Seager, A. Hooks, A. P. Williams, B. Cook, J. Nakamura and N. Henderson, "Climatology, Variability, and Trends in the U.S. Vapor Pressure Deficit, an Important Fire-Related Meteorological Quantity," *Journal of Applied Meteorology and Climatology,* pp. 1121-1141, 2015.

[3] B. Zhao, J. Huntington, C. Pearson, G. Zhao, T. Ott, J. Zhu, A. Weinberg, K. D. Holman, S. Zhang, R. Anderson, M. Strickler, J. Cotter, N. Fernando, K. Nowak and G. Huilin, "Developing a General Daily Lake Evaporation Model and Demonstrating Its Application in the State of Texas," *Water Resources Research,* 2024.

[4] E. Maloney, S. J. Camargo, E. Chang, B. Colle, R. Fu, K. L. Geil, Q. Hu, X. Jiang, N. Johnson, K. B. Karnauskas, J. Kinter, B. Kirtman, S. Kumar, B. Langenbrunner, K. Lombardo, L. N. Long, A. Mariotti, J. E. Meyerson, K. C. Mo, D. Neelin, Z. Pan, R. Seager, Y. Serra, A. Seth, J. Sheffield, J. Stroeve, J. Thibeault, S.-P. Xie, C. Wang, B. Wyman and M. Zhao, "North American Climate in CMIP5 Experiments: Part III: Assessment of Twenty-First-Century Projections," *Journal of Climate,* pp. 2230-2270, 2014.

[5] S. Pfahl, P. O'Gorman and E. Fischer, "Understanding the regional pattern of projected future changes in extreme precipitation," *Nature Climate Change,* pp. 423-427, 2017.

[6] M. K. Cleaveland, T. H. Votteler, D. K. Stahle, R. C. Casteel and J. L. Banner, "Extended Chronology of Drought in South Central, Southeastern, and West Texas," *Texas Water Journal,* pp. 54-94, 2011.

[7] N. W. Service, "NOAA Online Weather Data," NOAA, [Online]. Available: https://www.weather.gov/wrh/Climate?wfo=fwd.

[8] NEMAC, "The Climate Explorer," [Online]. Available: https://crt-climate-explorer.nemac.org/.

[9] ESGF, "CMIP5," [Online]. Available: https://aims2.llnl.gov/search/cmip5/.

[10] "Data.gov," [Online]. Available: https://catalog.data.gov/dataset/projected-future-loca-statistical-downscaling-localized-constructed-analogs-statistically-downs.

[11] D. van Vuuren, E. Kriegler, B. O'Neill, K. Ebi, K. Riahi, T. Carter, J. Edmonds, S. Hallegatte, T. Kram, T. Mathur and H. Winkler, "A new scenario framework for Climate Change Research: scenario matrix architecture," *Climatic Change,* vol. 122, pp. 373-386, 2014.

[12] B. Sanderson and M. Wehner, "Climate Science Special Report: Fourth National Climate Assessment, Volume I," U.S. Global Change Research Program, [Online]. Available: https://science2017.globalchange.gov/chapter/appendix-b/.

[13] J. Runkle, K. Kunkel, J. Nielsen-Gammon, R. Frankson, S. Champion, B. Stewart, L. Romolo and W. Sweet, "State Climate Summaries 2022 Texas," NOAA, 2022. [Online]. Available: https://statesummaries.ncics.org/chapter/tx/.

[14] M. Igini, "Water Shortage in Texas: Causes, Effects and Solutions," Earth.org, 19 April 2022. [Online]. Available: https://earth.org/water-shortage-in-texas/.

[15] T. 2036, "Texas' Future Depends on Extreme Weather Preparedness, New Studies Show," 2021. [Online]. Available: https://texas2036.org/posts/texas-future-depends-on-extreme-weather-preparedness-new-studies-show/.

[16] U. G. C. R. Program, "FOURTH NATIONAL CLIMATE ASSESSMENT Volume II: Impacts, Risks, and Adaptation in the United States," 2019. [Online]. Available: https://nca2018.globalchange.gov/.

[17] EPA, "What Climate Change Means for Texas," August 2016. [Online]. Available: https://www.epa.gov/sites/default/files/2016-09/documents/climate-change-tx.pdf.

[18] Y. Schumacher, A. Ford and E. Douglas, "Climate change has sent temperatures soaring in Texas," Texas Tribune, 27 June 2023. [Online]. Available: https://www.texastribune.org/2023/06/27/texas-climate-change-heat/#:~:text=Record%2Dbreaking%20heat%20is%20becoming,range%20of%20typical%20temperatures%20higher..

[19] M. Igini, "4 Environmental Issues in Texas in 2023," Earth.org, 1 July 2023. [Online]. Available: https://earth.org/texas-climate-change/.

Appendix J. Adopted City Council Resolution Authorizing DWU Staff to Include Recommended and Alternative Strategies in the 2024 LRWSP

This page intentionally left blank to serve as a placeholder for future authorization documents.

This Page Intentionally Blank.

Appendix K: Letter for Region C Water Supply Group

This page intentionally left blank to serve as a placeholder for a future letter to the Region C Regional Planning Group.

This Page Intentionally Blank

Appendix L: Recommended and Alternative Strategy Fact Sheets

This page intentionally left blank to serve as a placeholder for fact sheets on the 2024 LRWSP's Recommended and Alternative Strategies that will be included with the final version of the plan.

This Page Intentionally Blank

Appendix M: 2024 Dallas LRWSP – Costing Assumptions and Methodologies: Use of the TWDB Unified Costing Model for Regional Water Planning in the Development of the Dallas Long Range Water Supply Plan

The Texas Water Development Board (TWDB) compiles cost estimates from all 16 planning regions and uses the information to develop the State Water Plan. With the Unified Costing Model (UCM), TWDB gained a level of consistency between cost estimates developed for the 16 Regional Water Planning Groups and their consultants. This, in turn, assures that cost estimates in the State Water Plan are consistent and on equal footing. The UCM is intended to assist regional water planning groups and their consultants in developing consistent cost estimates across the State of Texas, so when these 16 regional plans come together to form the State Water Plan, TWDB can be assured that each water management strategy is evaluated on an even playing field with respect to cost estimates. The 2024 Dallas LRWSP uses the UCM and similar assumptions as those used in development of the 2026 Regional Plans to provide some level of consistency between the documents.

The UCM is designed to be relatively intuitive, with individual component modules, some of which are optional, that feed information to a line-item costing form, automatically when possible. The UCM contains a series of modules to aid the user in developing a cost estimate for a water management strategy under consideration in planning level studies.

HDR selected the UCM for use in the development of the Dallas Long Range Water Supply Plan for several reasons including the ability to quickly modify the UCM with assumptions that are particular to the Dallas LRWSP. For each potential strategy, a planning level costing analysis was developed using the UCM. All costs are estimated based on September 2023 prices, unless otherwise noted.

Summary of planning level costing assumptions for the LRWSP:

- The TWDB Unified Costing Model (UCM), provides consistent cost estimates for the 16 Regional Water Planning Groups, and is a useful tool for Dallas to use in the LRWSP.
- The UCM is designed to aid the user in developing a planning level cost estimate for a water management strategy under consideration in planning level studies. It was developed by HDR for use by the TWDB for regional planning.
- For each potential strategy, a planning level costing analysis was developed using the UCM, unless a more detailed or up to date estimate was available from other studies, such as the IPL.

- All costs are estimated based on September 2023 prices, unless otherwise noted.
- Costing analysis includes
    - preliminary pipeline routing and hydraulic analysis
    - pipeline diameters and pump station requirements
    - Other infrastructure components: dams, intakes, groundwater well fields, water treatment plants, etc.
    - Debt service is based on an interest rate of 3.5% financed across 20 years for reservoirs and 40 years for non-reservoirs, a 2026 Region C planning assumption.
    - Energy costs for pumping water were estimated based on an average rate of $0.09/kW-hr, a 2026 Region C planning assumption.
    - Costs for engineering, legal, and contingencies are estimated as 30% of capital costs for the pipeline and 35% of capital costs for other facilities (e.g., pump stations).
    - Costs for environmental and archeology studies and mitigation are estimated based on length of pipeline or inundated area of the reservoir.
    - Land costs were estimated based on 2023 rural land values from Texas A&M University Real Estate Center for each county.
    - Operation and maintenance costs are developed as a percentage (1% to 2.5%) of the capital cost for the infrastructure.

For the pipelines connecting to one of Dallas' transmission pipelines or reservoirs, a peaking factor of 1.05 was used for sizing and costing analyses. Strategies that deliver directly to one of Dallas' water treatment plants (WTPs) use a peaking factor of 1.25 unless previous studies used an alternative factor. Pipeline diameters and pump station requirements were based on system hydraulic conditions and were calculated using roughness factors (Hazen-Williams C) of 120, a minimum pressure of 15 psi at the high point, and a maximum allowable pipeline velocity of seven feet per second.

Large scale projects, such as reservoirs, may require the relocation of facilities such as buildings, utilities, and roads. These relocations are included in the capital costs and are subject to interest during construction and debt service.

A number of these strategies have previously been evaluated in other studies and, where appropriate, existing information concerning pipeline routing, diameter and pump station sizing were determined based on these studies. For new strategies, pipeline routes were generally routed along existing roadways for easier access during construction and maintenance. When an existing roadway was not available, routes were chosen that generally parallel existing utility right-of-ways to avoid structures while minimizing utility, road and stream crossings.

Debt service is based on an interest rate of 3.5% financed across 20 years for reservoirs and 40 years for non-reservoirs, a 2026 Region C planning assumption.. Energy costs for pumping are estimated based on an average energy cost of $0.09/kW-hr. The total dynamic head and horsepower required are calculated in the hydrologic analysis and used to calculate the required average pumping energy.

A 3.5% interim financing rate is used during construction. For a typical project, Dallas would fund construction by securing loans or selling bonds of some type. Dallas would receive these funds at the start of the construction of the project and would pay the contractor from these funds over the duration of the construction period. Interest on the borrowed funds will be charged during the construction period as well. Dallas would typically not want to make payments on the borrowed funds or interest until the project is complete and generating revenue. As such, the interim financing or interest during construction is determined and treated as a cost item to be included as part of the total project cost and made part of the loan. In addition, Dallas may invest part of the borrowed funds during the construction period and any gains made on the investment can be used to offset interest payments. A 0.5% return on investment is assumed during construction.

Total project and annual costs along with project yield are included in the description of each strategy. These costs include all construction costs as well as costs for engineering, legal, and contingencies which are estimated to be 30% of capital costs for pipelines and 35% of capital costs for other facilities (e.g., pump stations, reservoirs, and relocations). Costs for environmental and archeology studies and mitigation are estimated based on length of pipeline or inundated area of the reservoir. Land costs were estimated based on 2023 rural land value from Texas A&M University Real Estate Center[1] for each county. Unit costs are provided in units of dollars per acft and dollars per 1,000 gallons. Unit costs after the debt service is retired are also provided.

The TWDB UCM can be obtained at the following URL.

https://www.twdb.texas.gov/waterplanning/rwp/planningdocu/2026/projectdocs/costingtools/UCM_Version3.0.1.xlsbThe UCM User’s Guide can be obtained at the following URL.

https://www.twdb.texas.gov/waterplanning/rwp/planningdocu/2026/projectdocs/costingtools/UCM_Version3_UserGuide.pdfThe following figures provide examples of the modules contained in the UCM and used in the 2024 Dallas LRWSP.

[1] http://recenter.tamu.edu/data/rland/

Figure 1. UCM Reference Flow Chart

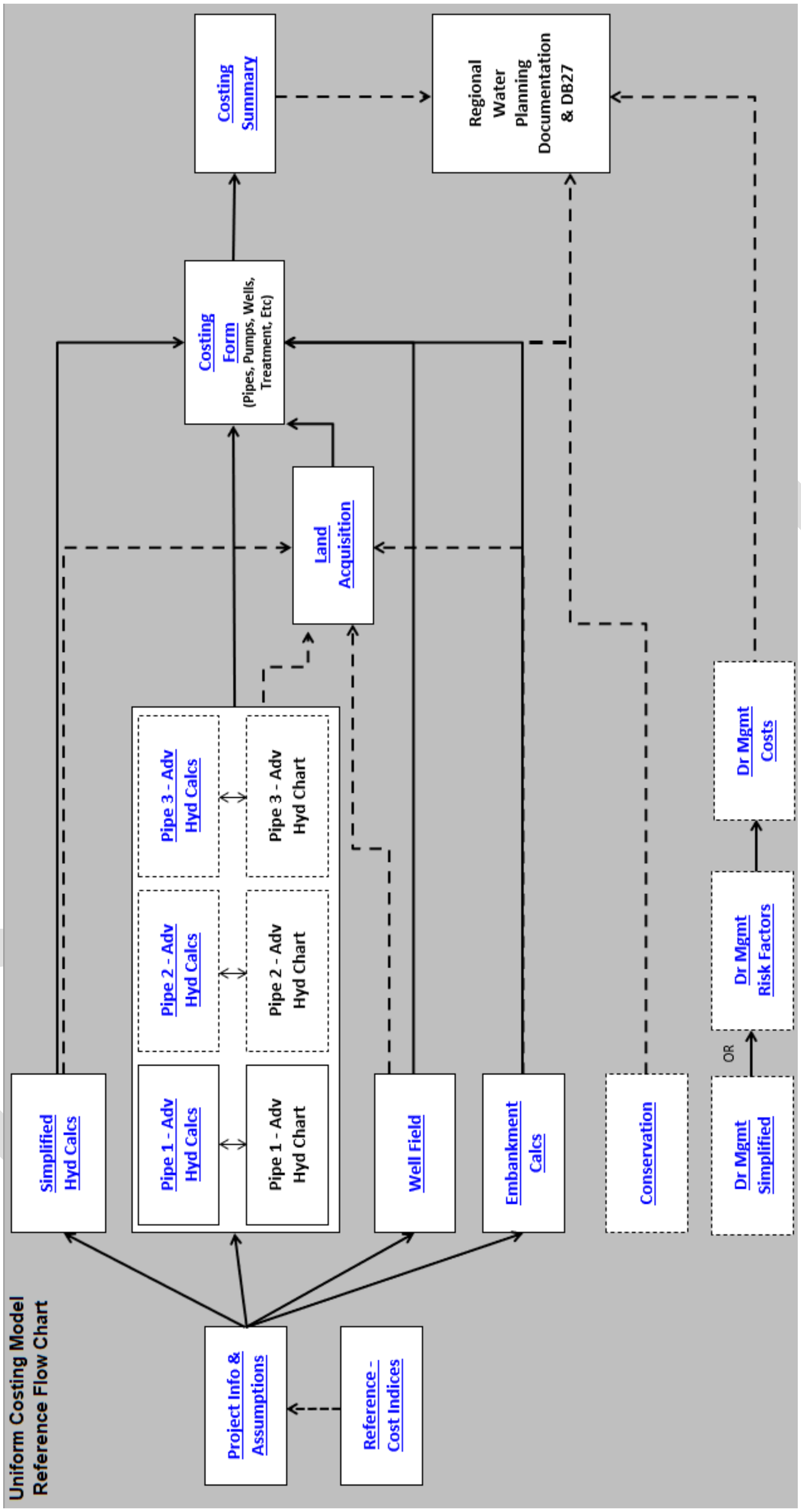


Figure 2. UCM Basic Information and Assumptions Module

TWDB - Uniform Costing Model for Regional Planning

Basic Info	Project Name:			
	WUG/WWP:			
	Cost Estimator:			
	Date for Estimation:			
	Checked By:			
	ENR Construction Cost Index Time Period:	September 2023	CCI Factor:	13486
	Producer Price Index Time Period:	September 2023	PPI Factor	278.5
	Available Project Yield		acft/yr	
	Conservation or Drought Management WMS?	No		
	Simplified or Advanced Hydraulics?	Simplified and Advanced		
	Number of Pipelines	1		
	Does the project include a wellfield?	No		
TWDB General Guidelines	Interest During Construction	3.50%		
	Rate of Return on Investments	0.50%		
	Construction Period	1.0	years	
	Engineering - Planning	3%		
	Engineering - Design	7%		
	Construction Engineering	1%		
	Legal Assistance	2%		
	Fiscal Services	2%		
	Contingency for Pipelines	15%		
	Contingency for All Other Facilities	20%		
	Debt Service (Non-Reservoirs) Period	20	years	
	Debt Service (Reservoirs) Period	40	years	
	Annual Interest Rate (Non-Reservoirs)	3.50%		
	Annual Interest Rate (Reservoirs)	3.50%		
	Operations & Maintenance (Pipelines)	1.00%	% of Capital Costs	
	Operations & Maintenance (Pump Stations)	2.50%	% of Capital Costs	
	Operations & Maintenance (Dams)	1.50%	% of Capital Costs	
	Power Costs	$0.09	/kilowatt-hour	
Pumps & Crossings	Power Connection Costs - Pump Stations	$200	/HP	
	Pump Station Tank Option	GST w/ Roof		
	Pump Station Tank(s) - % of Daily Flow for Sizing	10%		
	Recommended Crossing Length (2-Lane Roads)	115	LF	
	Recommended Crossing Length (4-Lane Divided Highway)	210	LF	
	Recommended Crossing Length (6-Lane Divided Highway)	240	LF	
	Recommended Crossing Length (Railways)	100	LF	

Figure 3. UCM Pipe Hydraulics (Advanced) Module

Pipe Sizing and Profile Plotting Spreadsheet
Lake Columbia
Z Stein Updated By C Nellis, C Burton
9/26/2024

ANRA: Pipeline Elevation Profile with Pressure Class Elevations

	Rural	Urban
SOIL	91,950	13,350
ROCK	0	0

Minimum PSI =	16	psi
Maximum PSI =	220	psi

Hydraulics

Downtime for Maintenance (Uniform Deli	5.0%	
Target Flow Velocity in Pipes	5.0	ft/s
Hazen-Williams C Factor (Roughness)	120	
Residual Head at End of Pipe	132	psi
Water Delivered (Raw or Treated)	Raw	
Pump Efficiency (Mechanical & Electrical	70%	
Pump Station Headloss	15.0	ft

Deliveries

Total Water Conveyance (acft/yr)	56000		
Peaking Factor	1.00		
Delivery Amount #1 (acft/yr)	56000	Station (ft)	105300
Delivery Amount #2 (acft/yr)		Station (ft):	
Delivery Amount #3 (acft/yr)		Station (ft):	
Delivery Amount #4 (acft/yr)		Station (ft):	
Delivery Amount #5 (acft/yr)		Station (ft):	

ArcGIS Pro Profile

Advanced Pipeline Hydraulics Calculations

Segment	Pipe Diameter (in)	Average Flow (MGD)	Peak Flow (MGD)	Peak Flow (cfs)	Computed Diameter for 5.0 ft/s (in)	Velocity (ft/s)	HGL Slope (c=120) (ft/1000 ft)	End Station (ft)	Pipe Pressure Class (psi)	Max Pressure (psi)
Segment 1	54	49.99	52.62	81.40	60	5.12	1.519	105,300	250	220
Segment 2		0.00	0.00	0.00	0	0.00	0.000			0
Segment 3		0.00	0.00	0.00	0	0.00	0.000			0

Pipeline Profile Data

Station (ft)	Ground Elevation (ft-msl)	Soil or Rock	Urban or Rural	Pressure: 250 psi (ft-msl)	HGL (ft-msl)	Hydraulic Calcs (psi)	Soil, Urban	Soil, Rural	Rock, Urban	Rock, Rural
0	320	Soil	Rural	897.50	828.90	220.30				
50	320	Soil	Rural	897.50	828.82	220.27	0.00	50.00	0.00	0.00
100	320	Soil	Rural	897.50	828.75	220.24	0.00	100.00	0.00	0.00
150	320	Soil	Rural	897.50	828.67	220.20	0.00	150.00	0.00	0.00
200	320	Soil	Rural	897.50	828.59	220.17	0.00	200.00	0.00	0.00
250	320	Soil	Rural	897.50	828.52	220.14	0.00	250.00	0.00	0.00
300	320	Soil	Rural	897.50	828.44	220.10	0.00	300.00	0.00	0.00
350	320	Soil	Rural	897.50	828.37	220.07	0.00	350.00	0.00	0.00

Figure 4. Example UCM Pipe Hydraulics Plot

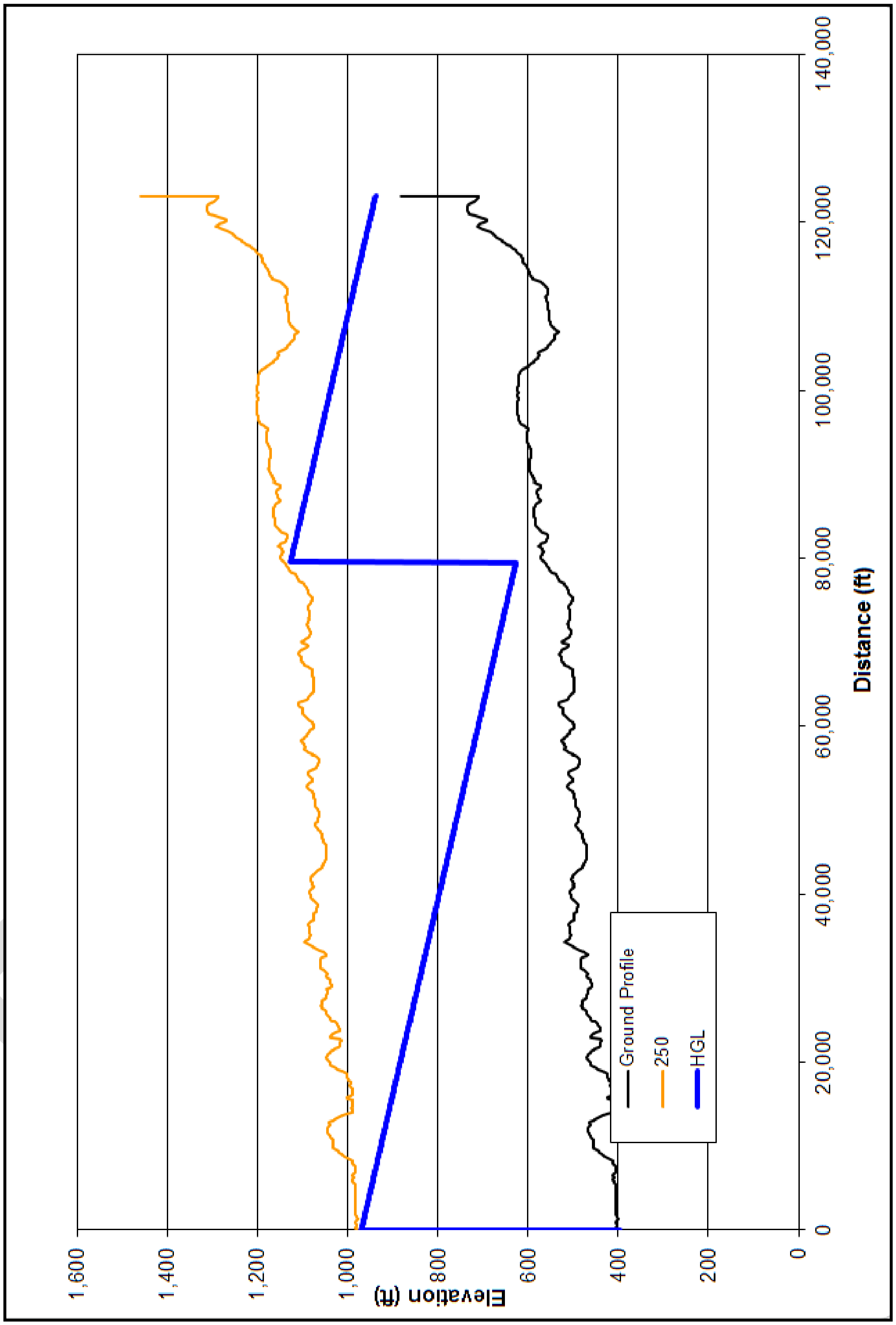


Figure 5. UCM Well Field Module

Well Field Calculations: Pipes and Pump Sizing

WUG/WWP: 0

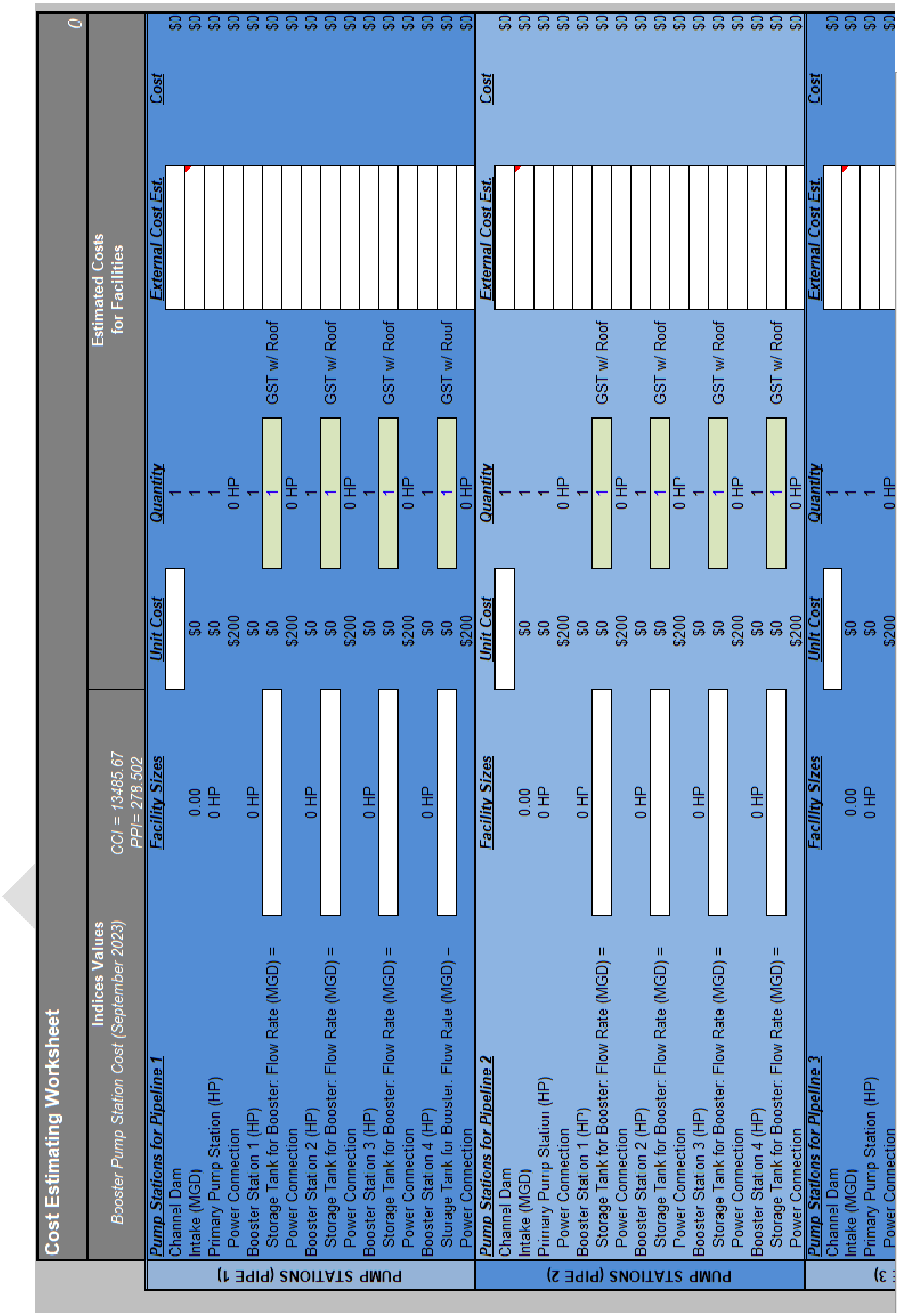
Note: Be sure to enter well field piping information in the Costing Form module

Avg. Static Water El (ft-msl):	-241
Drawdown:	298.88
Total Water Production (acft/yr):	7,661
Avg Well Field Yield (mgd):	6.84
Peaking Factor:	1
Well Pump Efficiency (%):	80%
Contingency Wells Needed (%):	15%
Well Station Losses:	22
Elevation of Delivery Point (ft-msl):	605
C Factor:	120

Avg Flow Per Well (gpm):	565
Peak Flow Per Well (gpm):	565
Avg Flow Per Well (cfs):	1.26 cfs
Peak Flow Per Well (cfs):	1.26 cfs
Active Wells Required (565 gpm per well)	9
Contingency Wells (15%)	2
Minimum Pipeline Pressure (psi):	35

	Well / Pipe Number	Peak Flow (gpm)	Peak Flow (cfs)	Computed Diameter[1] (in)	Selected Diameter (in)	Velocity (fps)	Length (ft)	Begin Elevation	DS Well/ Pipe Node	Elevation in DS Well/Pipe (ft)	Elevation Delta	TDH (ft)	HP	% Time Operating	Kw-hr	HGL Slope (ft/100ft) (c = 120)	Segment Pipe Head Loss
Well Field	1	565	1.26	8	8	3.61	200	560.00	A	560.00	0.00	1123.35	200.35	52.5%	688,056	7.36	1.47
	2	565	1.26	8	8	3.61	200	565.00	B	565.00	0.00	1128.35	201.24	52.5%	691,119	7.36	1.47
	3	565	1.26	8	8	3.61	200	570.00	C	570.00	0.00	1133.35	202.13	52.5%	694,181	7.36	1.47
	4	565	1.26	8	8	3.61	200	575.00	D	575.00	0.00	1138.35	203.02	52.5%	697,244	7.36	1.47
	5	565	1.26	8	8	3.61	200	560.00	E	560.00	0.00	1123.35	200.35	52.5%	688,056	7.36	1.47
	6	565	1.26	8	8	3.61	200	565.00	F	565.00	0.00	1128.35	201.24	52.5%	691,119	7.36	1.47
	7	565	1.26	8	8	3.61	200	570.00	G	570.00	0.00	1133.35	202.13	52.5%	694,181	7.36	1.47
	8	565	1.26	8	8	3.61	200	575.00	H	575.00	0.00	1138.35	203.02	52.5%	697,244	7.36	1.47
	9	565	1.26	8	8	3.61	200	560.00	I	560.00	0.00	1123.35	200.35	52.5%	688,056	7.36	1.47
	10	565	1.26	8	8	3.61	200	565.00	J	565.00	0.00	1128.35	201.24	52.5%	691,119	7.36	1.47
	11	565	1.26	8	8	3.61	200	570.00	K	570.00	0.00	1133.35	202.13	52.5%	694,181	7.36	1.47
	12	565	1.26	8	8	3.61	200	575.00	L	575.00	0.00	1138.35	203.02	52.5%	697,244	7.36	1.47
	13	565	1.26	8	8	3.61	200	560.00	M	560.00	0.00	1123.35	200.35	52.5%	688,056	7.36	1.47
	14	565	1.26	8	8	3.61	200	565.00	N	565.00	0.00	1128.35	201.24	52.5%	691,119	7.36	1.47
	15	565	1.26	8	8	3.61	200	570.00	O	570.00	0.00	1133.35	202.13	52.5%	694,181	7.36	1.47
	16	565	1.26	8	8	3.61	200	575.00	P	575.00	0.00	1138.35	203.02	52.5%	697,244	7.36	1.47
Trunkline	A	565	1.26	8	8	3.61	2,500	560.00	B	565.00	5.00	104.25	18.59	52.5%	63,854	7.36	18.40
	B	1,130	2.52	12	12	3.21	2,500	565.00	C	570.00	5.00	14.22	5.07	52.5%	17,421	3.69	9.22
	C	1,695	3.78	14	14	3.53	2,500	570.00	D	575.00	5.00	14.22	7.61	52.5%	26,134	3.69	9.22
	D	2,260	5.04	14	14	4.71	2,500	575.00	H	575.00	0.00	15.71	11.21	52.5%	38,496	6.29	15.71
	E	565	1.26	8	8	3.61	2,500	560.00	F	565.00	5.00	23.40	4.17	52.5%	14,333	7.36	18.40
	F	1,130	2.52	12	12	3.21	2,500	565.00	G	570.00	5.00	14.22	5.07	52.5%	17,421	3.69	9.22
	G	1,695	3.78	14	14	3.53	2,500	570.00	H	575.00	5.00	14.22	7.61	52.5%	26,134	3.69	9.22
	H	4,520	10.07	20	20	4.62	2,500	575.00	L	575.00	0.00	9.99	14.25	52.5%	48,931	3.99	9.99
	I	565	1.26	8	8	3.61	2,500	560.00	J	565.00	5.00	23.40	4.17	52.5%	14,333	7.36	18.40
	J	1,130	2.52	12	12	3.21	2,500	565.00	K	570.00	5.00	14.22	5.07	52.5%	17,421	3.69	9.22
	K	1,695	3.78	14	14	3.53	2,500	570.00	L	575.00	5.00	14.22	7.61	52.5%	26,134	3.69	9.22
	L	6,780	15.11	24	24	4.81	2,500	575.00	P	575.00	0.00	8.71	18.64	52.5%	64,000	3.48	8.71
	M	565	1.26	8	8	3.61	2,500	560.00	N	565.00	5.00	23.40	4.17	52.5%	14,333	7.36	18.40
	N	1,130	2.52	12	12	3.21	2,500	565.00	O	570.00	5.00	14.22	5.07	52.5%	17,421	3.69	9.22
	O	1,695	3.78	14	14	3.53	2,500	570.00	P	575.00	5.00	14.22	7.61	52.5%	26,134	3.69	9.22

Figure 6. UCM Detailed Costing Form Module



Cost Estimating Worksheet 0

Indices Values		Estimated Costs for Facilities				
Booster Pump Station Cost (September 2023)	CCI = 13485.67 PPI= 278.502					

PUMP STATIONS (PIPE 1)

Pump Stations for Pipeline 1	Facility Sizes	Unit Cost	Quantity		External Cost Est.	Cost
Channel Dam			1			$0
Intake (MGD)	0.00	$0	1			$0
Primary Pump Station (HP)	0 HP	$0	1			$0
Power Connection		$200	0 HP			$0
Booster Station 1 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 2 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 3 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 4 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0

PUMP STATIONS (PIPE 2)

Pump Stations for Pipeline 2	Facility Sizes	Unit Cost	Quantity		External Cost Est.	Cost
Channel Dam			1			$0
Intake (MGD)	0.00	$0	1			$0
Primary Pump Station (HP)	0 HP	$0	1			$0
Power Connection		$200	0 HP			$0
Booster Station 1 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 2 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 3 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0
Booster Station 4 (HP)	0 HP	$0	1			$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1	GST w/ Roof		$0
Power Connection		$200	0 HP			$0

(3)

Pump Stations for Pipeline 3	Facility Sizes	Unit Cost	Quantity		External Cost Est.	Cost
Channel Dam			1			$0
Intake (MGD)	0.00	$0	1			$0
Primary Pump Station (HP)	0 HP	$0	1			$0
Power Connection		$200	0 HP			$0

Figure 7. UCM Cost Summary Output Table

Cost Estimate Summary *Water Supply Project Option* *September 2023 Prices*	
Cost based on ENR CCI 13485.67 for September 2023 and a PPI of 278.502 for September 2023	
Item	***Estimated Costs for Facilities***
Off-Channel Storage/Ring Dike (Conservation Pool 300000 acft, 4337 acres)	$282,129,000
Intake Pump Stations (127.5 MGD)	$127,285,000
Transmission Pipeline (72-90 in. dia., 38.3 miles)	$642,549,000
Transmission Pump Station(s) & Storage Tank(s)	$75,339,000
Integration, Relocations, Backup Generator & Other	$15,652,000
TOTAL COST OF FACILITIES	**$1,142,954,000**
- Planning (3%)	$34,289,000
- Design (7%)	$80,007,000
- Construction Engineering (1%)	$11,430,000
Legal Assistance (2%)	$22,859,000
Fiscal Services (2%)	$22,859,000
Pipeline Contingency (15%)	$96,274,000
All Other Facilities Contingency (20%)	$100,225,000
Environmental & Archaeology Studies and Mitigation	$48,977,000
Land Acquisition and Surveying (4584 acres)	$50,910,000
Interest During Construction (3.5% for 3 years with a 0.5% ROI)	$156,315,000
TOTAL COST OF PROJECT	**$1,767,099,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$87,010,000
Reservoir Debt Service (3.5 percent, 40 years)	$24,487,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$6,796,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$4,529,000
Dam and Reservoir (1.5% of Cost of Facilities)	$4,232,000
Water Treatment Plant	$0
Advanced Water Treatment Facility	$0
Pumping Energy Costs (124098746 kW-hr @ 0.09 $/kW-hr)	$11,169,000
Purchase of Water (acft/yr @ $/acft)	$0
TOTAL ANNUAL COST	**$138,223,000**
Available Project Yield (acft/yr)	114,337
Annual Cost of Water ($ per acft), based on PF=1.25	$1,209
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.25	$234
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.25	$3.71
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.25	$0.72
Note: One or more cost element has been calculated externally	

This Page Intentionally Left Blank

Appendix N. Water Conservation Model

This page intentionally left blank to serve as a placeholder for 2024 LRWSP Water Conservation Model to be delivered to DWU at a later date.

This Page Intentionally Left Blank

Appendix O. RiverWare Model Update and Model Components

Memo: RiverWare Model Update Description

Date:	April 23, 2024
Project:	Dallas Long Range Water Supply Plan
To:	Semu A. Moges, Ph.D., P.E. - DWU
From:	Zach Stein, PE - HDR Caroline Nellis - HDR
Subject:	Dallas RiverWare Hydrology Extension

1 Introduction

Dallas Water Utilities (DWU) staff has undertaken the effort to continuously extend the naturalized reservoir inflow, precipitation, and lake evaporation datasets included in the Dallas RiverWare model. DWU has performed these updates for the 2008-2020 period and requested that HDR complete an independent technical review of the data. To verify these updates and to create an efficient and user-friendly process for future hydrology extensions, HDR developed a mass balance excel workbook for the 10 reservoirs and Elm Fork run of river naturalized flows included in the RiverWare model for the 2008- 2020 period. The methodology used to develop the mass balance spreadsheets and steps needed to extend the period of record in the spreadsheets in the future is described in the following sections.

2 Reservoir Methodology

The extension of naturalized streamflow was accomplished using similar methodology as the original streamflow naturalization with the exception being the location of naturalized flow calculations. Previously, for the existing period, 1907-2007, the TCEQ naturalized flow Excel workbooks were used to perform calculations at select gage locations. Calculations at the gage locations accounted for upstream reservoir content changes and net evaporative losses. Naturalized flows were then translated from the gages to the reservoirs for insertion into the RiverWare model by adjusting for differences in drainage areas. For the 2008-2020 naturalized flow extension, a water balance approach was used to naturalize flows at the downstream side of each reservoir.

The rest of the methodology was similar to what was performed for the existing period where naturalized streamflow data were based on historical flows and adjusted to remove the effects of water management activities. Naturalized streamflows were calculated on a monthly timestep for consistency with the existing dataset and the simulation timestep of the Dallas RivereWare model. As a result of the monthly timestep, travel time is neglected in the streamflow naturalization procedures. The following equation was used to calculate naturalized streamflow for 10 reservoirs and at the Elm Fork run of river:

> Naturalized Flow = Change in Reservoir Storage – Net Evaporation Loss + Upstream Diversions – Upstream Return Flows + Releases and Spills (+ transfers if applicable).

Extending the evaporation datasets was accomplished using substantially the same methodology used in the development of the existing datasets and is based on the following equation:

> Net evaporation = (gross evaporation – rainfall + runoff adjustment) x average surface area of the current and previous month.

Channel losses were not included in the development of the existing naturalized streamflow dataset as they were assumed to represent a negligible component of the water balance in the Neches, Sabine, Sulfur, and Trinity River Basins.

The calculation of monthly naturalized flows by reservoir mass balance occasionally results in negative values for some months due to timing of storm events and the accuracy of hydrologic and water management data. Negative naturalized flows must be corrected before insertion into the RiverWare model. Therefore, inflow adjustments for negative naturalized flows were made by setting negative flows to zero in existing calculations and surrounding months were adjusted to preserve mass balance in the final natural inflows.

For each of the 10 dams and Elm Fork run of river, final natural inflows are calculated in a mass balance sheet in individual excel workbooks. Within each reservoir's excel workbook, the mass balance sheet pulls in data from the other sheets in the workbook. The other sheets are used to enter raw data for the mass balance sheet to use in its calculations. Inflow adjustments were made as needed for each reservoir as described in the preceding paragraph once all of the other data was input into the reservoir's naturalized inflow mass balance Excel workbook. Data contained in each sheet of the reservoir's workbooks are described in the subsections below. The methodology is slightly different for the Elm Fork Trinity (Carrolton and Frasier Dams) and is described in its own section at the end of this memo.

2.1 Reservoir_ReadMe

The read me sheet describes the sources for all data that was obtained for the other sheets in the workbook.

2.2 Reservoir_MassBalance

The mass balance sheet pulls in data from the other worksheets in the workbook to calculate the final natural inflows that were used as inputs in the RiverWare model using the equations outlined in the beginning of the methodology section. Inflow adjustments for negative naturalized flows as described in the methodology section were made in this sheet once all other sources of data had been updated to find the final natural inflows that were used as inputs into the RiverWare model.

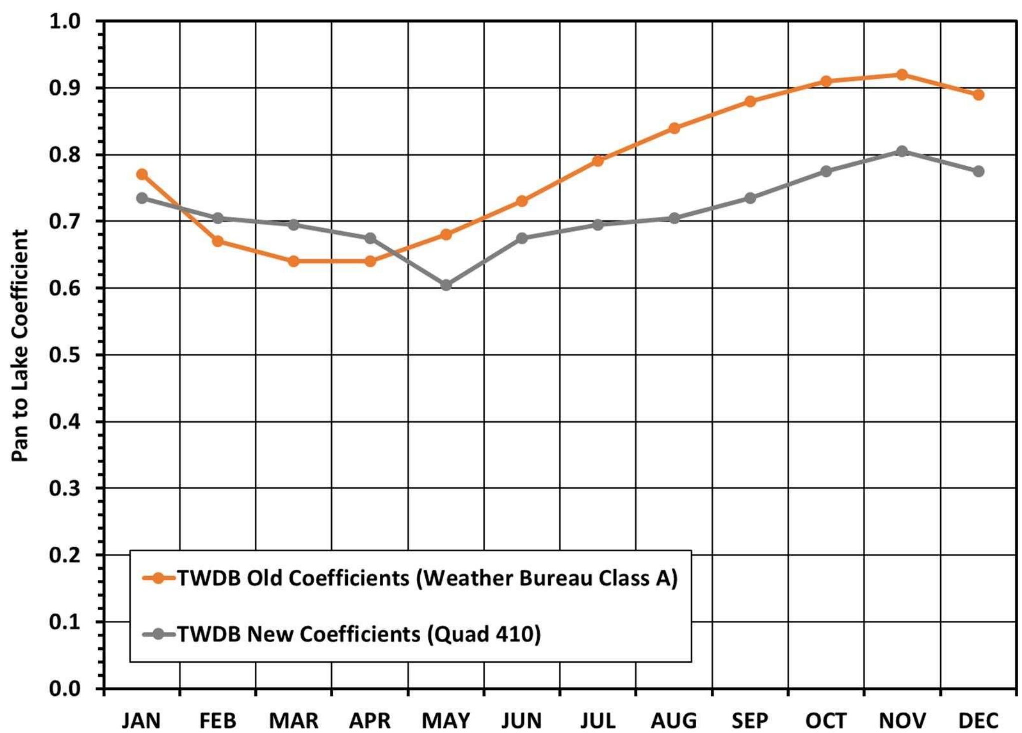
2.3 Reservoir_Evap

The reservoir evaporation sheet contains gross reservoir evaporation data obtained from the Texas Water Development Board (TWDB) quadrangle data. The quadrangle data was applied to each reservoir using weighting factors based on the approximate centroid of each reservoir. The weighting factors were obtained from the TCEQ naturalized flow Excel workbooks that were used to develop the existing naturalized flow data (1907-2007). The TWDB quadrangle evaporation data was used instead of station data from NOAA or NWS because the station data can be less reliable in terms of having a complete dataset and individual stations can be taken offline. The TWDB quadrangle data proves to be more reliable because it averages data across multiple weather stations.

For the evaporation data, pan to lake evaporation coefficients were applied to measured pan depths to estimate historical gross evaporation from reservoirs. Previous analysis by HDR as part of the hydrology development for the RiverWare model (see 11 January 2011 memo) found the "New" TWDB coefficients to underestimate lake evaporation in Dallas reservoirs. The previous HDR analysis found NWS Class A Pan coefficients more accurately estimate reservoir evaporation and these coefficients were applied in the development of the reservoir evaporation estimates for the existing period, 1997-2007, and were therefore also used for the period of extension, 2008-2020. Figure 1 compares the “New” TWDB Quad 410 and Class A monthly pan to lake coefficients. The new TWDB coefficients would underestimate reservoir evaporation by more than 10 percent compared to the Class A coefficients in the summer and fall months when evaporation rates are usually the highest. The NWS Class A coefficients are given in Table 1.

There is one exception to using the NWS Class A Pan Coefficients. For reservoirs in the Neches basin, an HDR supplemental evaluation for the Neches WAM report1 indicated that pan coefficients developed for the Young Screened Pan applied to Class A pan data provide a more accurate estimation of gross evaporation in the Neches River Basin. Therefore, for Lake Palestine, the Young Screened Pan coefficients were used instead of the TWDB pan coefficients.

Figure 1: Monthly Pan to Lake Coefficient Comparison



[1]HDR Engineering: Neches River Basin Water Availability Model (TCEQ Contract 582-20-13328) August 27, 2021.

Table 1: National Weather Service Class A Pan Coefficients

Month	NWS Class A Pan Coefficients
January	0.77
February	0.67
March	0.64
April	0.64
May	0.68
June	0.73
July	0.79
August	0.84
September	0.88
October	0.91
November	0.92
December	0.89

Table 2: Young Screened Pan Coefficients

Month	Young Screened Pan Coefficients
January	0.97
February	0.87
March	0.81
April	0.79
May	0.81
June	0.91
July	1.03
August	1.12
September	1.19
October	1.21
November	1.19
December	1.1

2.4 Reservoir_Precip

The precipitation sheet contains precipitation data from the National Weather Service (NWS) or the National Oceanic and Atmospheric Administration (NOAA) when gage data for the reservoir was available. Data gaps were infilled with rainfall data from the Texas Water Development Board (TWDB) quadrangle data using the same weighting equations used for evaporation. The below list outlines the source of precipitation data for each reservoir.

- Tawakoni: NOAA station USC00414980 LAKE TAWAKONI, TX US
- Fork: NOAA station USC00414976 LAKE FORK RESERVOIR, TX US
- Palestine: TWDB Quadrangle data
- Chapman: NWS (https://www.weather.gov/fwd/cooperclimatology) for Lake Cooper.
- Grapevine: NWS (https://www.weather.gov/fwd/grapevineclimatology) for Grapevine Dam.
- Joe Pool: NWS (https://www.weather.gov/fwd/joepoollakeclimatology) for Joe Pool Lake.

- Lavon: NWS (https://www.weather.gov/fwd/lavondamclimatology) for Lavon Dam.
- Ray Hubbard: Due to the close proximity of the two reservoirs and data only being available for Lake Lavon, the precipitation from the NWS for Lavon Dam was used for Ray Hubbard.

2.5 Reservoir_RunoffAdjustment

The runoff adjustment sheet accounts for the runoff from rainfall that would have resulted in the absence of the reservoir. Monthly streamflow data from the United States Geological Survey (USGS) is converted to a unit runoff depth using the contributing drainage area of the streamflow gage.

Runoff Adjustment (runoff depth) = discharge/drainage area of the closest USGS gage

2.6 Reservoir_WaterUse

The water use sheet contains upstream diversion data accessed from TCEQ. Earlier data, 2008-2014, was accessed from the water use data file entitled "From 2000 through 2014" which was accessed from https://www.tceq.texas.gov/permitting/water_rights/wr-permitting/wrwud. More recent data, 2014-2020, was obtained from the TCEQ water rights viewer: https://www.tceq.texas.gov/gis/water-rights-viewer.

2.7 Reservoir_ReturnFlow

The return flow sheet contains data for upstream monthly average return flows, expressed as "Flow, in conduit or thru treatment plant," that were downloaded from the United States Environmental Protection Agency's NPDES Monitoring Data Download site: https://echo.epa.gov/trends/loading-tool/get-data/monitoring-data-download. Lake Ray Hubbard is a special case where return flows were accounted for at Forney Pump Station (return flows could flow to the reservoir or downstream of the reservoir but upstream of the Forney Pump Station).

2.8 Reservoir_EAC

The Elevation-Area-Capacity (EAC) sheets contain EAC curves downloaded from the reservoir section of the Texas Water Development Board's (TWDB) Water Data for Texas website: https://www.waterdatafortexas.org/reservoirs/statewide. Area data associated with extrapolated elevations were calculated using the equation from a trendline of the non-extrapolated reservoir elevation and area data. These data were used to provide surface area and volume data at specific historical water levels in the Reservoir_ElevationEACInterpCalcs sheet.

2.9 Reservoir_ElevationEACInterpCalcs

This sheet contains period of record data downloaded from the reservoir section of the Texas Water Development Board's (TWDB) Water Data for Texas website: https://www.waterdatafortexas.org/reservoirs/statewide. Data used from the download includes date, water level, surface area, and reservoir storage. Surface Area and volume data was interpolated for each daily historical water level by referencing data in the Reservoir_EAC sheet and then summarized by month to get end of month volume values and average monthly surface area values for the reservoir to be used in the mass balance.

2.10 Reservoir_ReleaseSpill

For most of the reservoirs, any releases or spills from the reservoir were provided by Dallas Water Utilities and were used without any adjustments. However, due to data gaps, data describing the releases and spills for Palestine were obtained by contacting the Upper Neches River Municipal Water Authority for their historical releases.

2.11 Reservoir_Transfers

When applicable, transfers between reservoirs were obtained from Dallas Water Utilities and were used without any adjustments. This applies to Lavon as the reservoir transfers from Chapman and Texoma.

2.12 Base Data_1907-2007 monthly

Inflows for each reservoir for 1907-2007 were obtained from the RiverWare model to be used in graphical comparison in the mass balance sheet to ensure that the calculated 2008-2020 naturalized inflows fit with the existing inflows.

3 Elm Fork Trinity Methodology

Since Carrolton and Frasier dams do not have large reservoirs associated with them, the naturalized flow extension methodology was slightly different than the other reservoirs. The extension calculations for Carrolton/Frazier dam utilize return flows, diversions, and stream gages on Denton Creek near Grapevine (USGS Gage 08055000), the Elm Fork at Spur 348 (USGS Gage 08055560), the Elm Fork near Lewisville (USGS Gage 08053000) and the Elm Fork near Carrolton (USGS 08055500) combined with rainfall from National Weather Service (https://www.weather.gov/fwd/dallasloveclimatology) to calculate naturalized streamflow originating downstream of Lake Lewisville and Lake Grapevine and upstream of Carrolton Dam. Runoff at Carrolton Dam is then translated to Frasier Dam by adjusting for differences in contributing drainage areas before any necessary inflow adjustments for negative natural flows were made.

4 Steps for Future Mass Balance Extension

For future planning efforts, the mass balance spreadsheets are set up to be updated and extended past the current period of record. Use the Read Me sheet and source notes at the top of individual sheets to identify where raw data was obtained from. For timeseries data such as rainfall, evaporation, discharge for the runoff adjustment, water use, return flows, releases and spills, and elevation, input the raw data for the future extension period in the relevant sheet in the mass balance workbook then extend any columns that use an equation to compile or interpolate between the raw data in those sheets.

Be mindful of any data gaps, data irregularities, or new information as the raw data is input. Use engineering judgement to address these issues. Examples of common issues include when return flow data is an order of magnitude off because a decimal was not entered in the database or where rainfall data was obtained from a gage that went offline for a month or two so the TWDB quadrangle data was used to infill months with missing data. In terms of new information, for the return flows and water use, ensure that no new water rights or permits have been issued in the watershed upstream of the reservoir. For the EAC sheet, ensure that the most recent rating curve for the reservoir is used. If a more recent rating curve is available, replace the old curve data with the new curve data and use an equation obtained from a graph of elevation vs capacity to interpolate areas past conservation pool as needed. As gaps are filled, irregularities corrected, and new information is brought in, make notes of the changes throughout the workbook and in the Read Me sheet.

Once all of the sheets have been updated that the Mass Balance sheets pulls data from, select the last row of data in the Mass Balance sheet and extend the equations down to the end of the new period of record. Then make any necessary inflow adjustments for negative natural inflows.

Inflow adjustments will need to be made in the ‘Inflow Adjustments for Negative Nat Flow’ sheet for any month where there is a negative number in the ‘Initial Natural Inflow’ column. In the month where the negative occurs, the adjustment is made by putting the absolute value of the negative initial natural inflow in the ‘Inflow Adjustments for Negative Nat Flow’ column (see Figure 2 cell M100). To preserve mass balance in the final natural inflows, the amount of water added in the ‘Inflow Adjustments for Negative Nat Flow’ column must be removed from a surrounding month in that same column (see Figure 2 cell M101). To ensure that no inflows are accidentally added or decreased in the overall mass balance, the sum of the Inflow Adjustment Check (see Figure 2 cell M2) must be zero. To ensure that all negative natural inflows have been corrected, the minimum number given in the Inflow Adjustments Completed Check (see Figure 2 cell N2) must be zero. Once these checks are true, the Final Natural Inflows can be referenced in the Base Data_1907-2007 monthly sheet as the time period and equations are extended in that sheet. After this, the time period for the Cumulative Naturalized Inflow graph in the Mass Balance sheet can also be extended. This graph serves as a visual check to identify data anomalies in the Final Natural Inflows before the finalized inflows, precipitation, evaporation, and return flows are input into RiverWare to obtain updated firm and safe yields.

Figure 2: Negative Natural Inflow Adjustment Example

	A	L	M	N	O
1			Inflow Adjustment Check	Inflow Adjustments Completed Check	
2			0	0	
3					
4	**Joe Pool**				
5		ac-ft	ac-ft	ac-ft	
6	**Month/Year**	**Initial Natural Inflow**	**Inflow Adjustments for Negative Nat Flow**	**Final Natural Inflow**	
98	Jul-15	6,277		6,277	
99	Aug-15	738		738	
100	Sep-15	-49	49	0	
101	Oct-15	39,134	-49	39,085	
102	Nov-15	94,689		94,689	
103	Dec-15	41,807		41,807	

5 Description of RiverWare Model Options Used in 2024 LRWSP

Sediment Conditions – Sediment conditions for the two simulation years (2030 and 2080) are based on the elevation-area-capacity relationships used in the 2026 TWDB Regional Water Plans.

Flood Pool Storage – Flood pool releases for the Elm Fork reservoirs are based on USACE regulations. For all other reservoirs, releases from flood pool storage are based on the individual reservoir spillway rating curves.

Dead Pool Storage – Dead pool storage is assumed to be any storage below the lowest pump intake or gate release as specified by DWU staff during development of the RiverWare Model. Storage in the dead pool is not available for diversion to meet yield demands.

Temperature Increase from Climate Change – Temperature increase is the estimated average annual temperature increase predicted by climate models. Appendix B to this memorandum summarizes the findings of numerous climate models that predict, on average, that temperatures in Northeast Texas will increase by 1 degree F per decade beginning in about 2000 resulting in an estimated increase of 3 degrees F in 2030 and 8 degrees F by 2080 compared to historical average prior to 2000.

Naturalized Flow Set – Three naturalized flow sets were developed for the existing RiverWare model. Descriptions of the three flows are provided below.

1. Baseline – The baseline naturalized flow set is a combination of HDR derived flows from 1907 to 1940, WAM model (Water Availability Model) inflows from 1940 to 1997 and WAM extended flows from 1998 to 2020.

2. HDR – The HDR naturalized flow set is a combination of HDR derived flows from 1907 to 1957, model inflows from 1958 to 1997 and WAM extended flows from 1998 to 2020.

3. STELLA – The STELLA naturalized flow set are inflows from the DWU STELLA model for 1941 to 1987. STELLA is commercially available general purpose mathematical simulation modeling software.

The baseline naturalized flow set was used for all yield analyses.

LRH Urban Development – The drainage area below Lake Lavon and above Lake Ray Hubbard (LRH) has experienced significant urbanization. One impact of urbanization is increases in storm runoff from increases in impervious surfaces. The model has the option to utilize historical TCEQ WAM inflows with no adjustments for urbanization, adjust inflows under 2004 conditions or to adjust inflows under ultimate build-out conditions (which was previously predicted to occur prior to 2020). Historical inflows were assumed to estimate the supply available to Dallas from LRH.

Senior Pass Throughs - All or a portion of inflows to reservoirs are subject to downstream calls from senior water rights. When senior calls are made, inflows must be passed through the reservoir outlet works to the downstream senior water right holders. The existing model contains estimates of historical senior pass throughs for all reservoirs and these are included in all yield analyses.

Senior Upstream Depletions – Senior water right holders in the upper basin have the ability to deplete streamflows before being impounded by DWU reservoirs. The existing model contains estimates of historical upstream depletions and these are included in the yield analyses.

Return Flows – The model has the ability to introduce return flows from water reclamation facilities to various river reaches. The yield analyses include return flows as a part the reservoir inflows. Return flows in the RiverWare model are based on 2020 return flows if return flows were increasing or decreasing across the 2008-2020 period, Otherwise, return flows in the RiverWare model are based on 2008-2020 average return flows with the exception of NTMWD return flows into LRH. LRH is assumed to not have access to NTMWD's return flows because the swap agreement has not been executed and Dallas is required to pass these return flows through LRH.

Use of Return Flows – The model is capable of estimating the portion of return flows that are consumed before entering the various river reaches by entities upstream of the reservoirs. The yield analyses include the consumption of a portion of the return flows by upstream entities.

This Page Intentionally Blank

Appendix P. Comparison of Population Projections – 2014 LRWSP, 2026 Region C RWP, and 2024 LRSWP

Plan	2020	2030	2040	2050	2060	2070	2080
City of Addison							
2014 LRWSP	14,539	17,431	20,323	23,215	26,107	29,000	-
2026 Region C Plan	-	20,465	23,069	24,456	25,276	26,179	27,173
2024 LRWSP	-	20,465	23,069	24,456	25,276	26,179	27,173
City of Balch Springs							
2014 LRWSP	26,423	28,980	31,606	34,456	37,233	40,018	-
2026 Region C Plan	-	28,412	30,394	33,234	36,214	40,018	42,000
2024 LRWSP	-	28,412	30,394	33,234	36,214	40,018	42,000
City of Carrollton							
2014 LRWSP	126,763	129,176	129,179	129,182	129,185	129,188	-
2026 Region C Plan	-	141,268	149,561	158,341	167,636	177,477	178,153
2024 LRWSP	-	141,268	149,561	158,341	167,636	177,477	178,153
City of Cedar Hill							
2014 LRWSP	53,200	65,119	77,038	88,956	88,956	88,956	-
2026 Region C Plan	-	53,645	58,553	63,911	69,070	74,646	80,672
2024 LRWSP	-	53,645	58,553	63,911	69,070	74,646	80,672
City of Cockrell Hill							
2014 LRWSP	4670	5122	5122	5122	7000	15,000	-
2026 Region C Plan	-	3,610	3380	3255	3176	3089	2993
2024 LRWSP	-	3610	3380	3255	3176	3089	2993
Combine WSC							
2014 LRWSP	2,690	3,278	3,939	4,692	5,545	6,501	-
2026 Region C Plan	-	3,604	4,094	4,678	5,309	6,009	6,784
2024 LRWSP	-	3,604	4,094	4,678	5,309	6,009	6,784
City of Coppell							
2014 LRWSP	41,460	42,953	42,953	42,953	42,953	42,953	-
2026 Region C Plan	-	43,777	43,632	43,757	43,857	44,000	44,000
2024 LRWSP	-	43,777	43,632	43,757	43,857	44,000	44,000

*All values shown represent persons.

Plan	2020	2030	2040	2050	2060	2070	2080
DFW Airport							
2014 LRWSP	NA	NA	NA	NA	NA	NA	-
2026 Region C Plan	-	NA	NA	NA	NA	NA	NA
2024 LRWSP	-	NA	NA	NA	NA	NA	NA
City of Dallas							
2014 LRWSP	1,242,136	1,347,717	1,531,680	1,707,057	1,841,064	1,905,499	-
2026 Region C Plan	-	1,342,289	1,404,103	1,470,697	1,540,550	1,614,454	1,692,302
2024 LRWSP	-	1,393,479	1,508,053	1,647,570	1,804,405	1,959,091	2,142,389
City of DeSoto							
2014 LRWSP	54,617	59,903	65,330	71,222	76,963	82,718	-
2026 Region C Plan	-	59,901	63,934	66,069	67,304	68,664	70,162
2024 LRWSP	-	59,901	63,934	66,069	67,304	68,664	70,162
City of Duncanville							
2014 LRWSP	42,927	47,106	47,106	47,106	47,106	47,106	-
2026 Region C Plan	-	43,672	45,939	47,157	47,307	47,307	47,307
2024 LRWSP	-	43,672	45,939	47,157	47,307	47,307	47,307
City of Farmers Branch							
2014 LRWSP	30,613	32,509	34,455	36,567	38,625	40,689	-
2026 Region C Plan	-	36,454	39,795	41,570	42,609	43,754	45,014
2024 LRWSP	-	36,454	39,795	41,570	42,609	43,754	45,014
City of Flower Mound							
2014 LRWSP	75,555	93,000	93,000	93,000	93,000	93,000	-
2026 Region C Plan	-	95,690	119,876	145,420	145,481	145,555	145,555
2024 LRWSP	-	95,690	119,876	145,420	145,481	145,555	145,555
City of Glenn Heights							
2014 LRWSP	17,323	23,308	29,590	36,506	43,522	59,000	-
2026 Region C Plan	-	22,178	25,909	29,228	32,297	35,668	39,377
2024 LRWSP	-	22,178	25,909	29,228	32,297	35,668	39,377

*All values shown represent persons.

Plan	2020	2030	2040	2050	2060	2070	2080
City of Grand Prairie							
2014 LRWSP	218,162	258,759	283,493	283,515	283,541	283,571	-
2026 Region C Plan	-	223,551	250,447	281,412	289,414	300,401	300,401
2024 LRWSP	-	223,551	250,447	281,412	289,414	300,401	300,401
City of Grapevine							
2014 LRWSP	52,414	58,930	60,000	60,000	60,000	60,000	-
2026 Region C Plan	-	54,037	54037	54037	54037	54037	54037
2024 LRWSP	-	54037	54037	54037	54037	54037	54037
City of Hutchins							
2014 LRWSP	9,903	13,922	17,941	21,960	25,979	30,000	-
2026 Region C Plan	-	8,346	9,300	9,808	10,107	10,436	10,799
2024 LRWSP	-	8,346	9,300	9,808	10,107	10,436	10,799
City of Irving							
2014 LRWSP	260,752	284,500	284,500	284,500	284,500	284,500	-
2026 Region C Plan	-	285,073	302,931	303,163	303,400	303,641	303,641
2024 LRWSP	-	285,073	302,931	303,163	303,400	303,641	303,641
City of Lancaster/Lancaster MUD 1							
2014 LRWSP	45,184	58,895	69,717	77,649	85,582	93,514	-
2026 Region C Plan	-	46,953	50,263	52,017	53,034	54,154	55,387
2024 LRWSP	-	46,953	50,263	52,017	53,034	54,154	55,387
City of Wilmer							
2014 LRWSP	4203	4698	7500	14,000	22,000	40,000	-
2026 Region C Plan	-	5,902	6672	7081	7,324	7,591	7,885
2024 LRWSP	-	5902	6672	7081	7,324	7,591	7,885
City of Lewisville (inc. Denton County FWSD 1-A)							
2014 LRWSP	107,327	121,924	139,368	158,857	177,356	177,356	-
2026 Region C Plan	-	138,788	147,715	157,909	160,047	163,162	163,162
2024 LRWSP	-	138,788	147,715	157,909	160,047	163,162	163,162

*All values shown represent persons.

Plan	2020	2030	2040	2050	2060	2070	2080
City of Ovilla							
2014 LRWSP	4,525	5,791	7,249	8,946	10,917	20,000	-
2026 Region C Plan	-	5,438	6,827	8,337	9,871	11,556	13,411
2024 LRWSP	-	5,438	6,827	8,337	9,871	11,556	13,411
City of Red Oak							
2014 LRWSP	12369	14000	19000	26000	32,000	50,000	-
2026 Region C Plan	-	12,039	15,009	18,237	21,502	25,093	29,044
2024 LRWSP	-	12,039	15,009	18,237	21,502	25,093	29,044
City of Seagoville							
2014 LRWSP	18,854	22,873	26,892	30,911	35,000	35,000	-
2026 Region C Plan	-	20,875	22,892	23,964	24,593	25,285	26,047
2024 LRWSP	-	20,875	22,892	23,964	24,593	25,285	26,047
City of The Colony							
2014 LRWSP	51,000	58,000	62,000	67,600	67,600	67,600	-
2026 Region C Plan	-	51,496	60,502	67,600	67,600	67,600	67,600
2024 LRWSP	-	51,496	60,502	67,600	67,600	67,600	67,600
Upper Trinity Municipal Water District							
2014 LRWSP	364,350	501,727	616,702	750,215	840,481	947,594	-
2026 Region C Plan+	-	77,287	88,620	103,341	110,280	116,167	119,167
2024 LRWSP+	-	77,287	88,620	103,341	110,280	116,167	119,167
Combine							
2014 LRWSP	15,829	17,093	24,432	38,000	65,000	90,000	-
Denton							
2014 LRWSP	158,398	205,977	262,057	341,471	468,168	570,694	-
Gastonia-Scurry SUD							
2014 LRWSP	9,508	11,910	14,663	17,830	30,000	45,000	-
Oak Leaf							
2014 LRWSP	1,350	1,500	1,750	2,500	3,700	4,500	-
Dallas County-Other							
2014 LRWSP	5,339	3,000	2,000	2,000	2,000	2,000	-
DWU Total Customer Municipal Demand							
2014 LRWSP	**3,072,383**	**3,539,101**	**4,010,585**	**4,505,988**	**4,971,083**	**5,380,957**	**-**
2026 Region C Plan	**-**	**2,824,750**	**3,027,454**	**3,218,679**	**3,337,295**	**3,465,943**	**3,572,073**
2024 LRWSP	**-**	**2,875,940**	**3,131,404**	**3,395,552**	**3,601,150**	**3,810,580**	**4,022,160**

*All values shown represent persons.

+ Only cities receiving DWU water from UTRWD were included in the estimate and Flower Mound was excluded here because its population was included individually

This Page Intentionally Left Blank

Appendix Q: Implementation Timeline for Each Recommended Strategy

This page intentionally left blank to serve as a placeholder for implementation times lines for the Recommended Strategies that will be included with the final version of the plan.

This Page Intentionally Blank