dallas water utilities
city of dallas

City of Dallas

2014 Dallas Long Range Water Supply Plan to 2070 and Beyond

Dallas Water Utilities

City of Dallas, Texas
December 2015

HDR

The City of Dallas

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A special thanks to Janice Bezanson and David Marquis of the Texas Conservation Alliance for providing insight and suggestions on behalf of the environmental community.

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This report is dedicated to the memory of Colonel Bobby F. Praytor, Ph.D.

Bobby Praytor was a highly respected and key member of the City of Dallas Water Planning division, and was instrumental to long range water supply planning efforts for much of his 28 year tenure with Dallas Water Utilities.

2014 Dallas Long Range Water Supply Plan To 2070 and Beyond

Prepared for:
City of Dallas, Texas
Dallas Water Utilities

Prepared by:

HDR Engineering
Texas Firm P.E. Registration No. F-754

In association with:
Webb & Webb
CDM-Smith
Todd Groundwater
JQ Infrastructure
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December 2015

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2014 Dallas LRWSP Signature Page

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2014 LRWSP	2014 Dallas Long Range Water Supply Plan
AAWF	Average Annual Wastewater Flow
ADWF	Average Annual Dry-Weather Wastewater Flow
404	Section 404 of the Clean Water Act
acft/yr	Acre feet per year (1 acft = 325,851 gallons)
ANRA	Angelina Neches River Authority
BMP	Best Management Practice
CIP	Capital Improvements Program
CoA	Certificate of Adjudication
CWWTP	Central Wastewater Treatment Plant
D/FW	Dallas and Fort Worth
DWU	Dallas Water Utilities
EAC	Elevation-Area-Capacity
EIS	Environmental Impact Statement
GAM	Groundwater Availability Model
gpcd	Gallons Per Capita Per Day
IBT	Interbasin Transfer
ICI	Industrial, Commercial, and Institutional
IPL	Integrated Pipeline Project
LRWSP	Long Range Water Supply Plan
MAG	Modeled Available Groundwater
MGD	Million Gallons Per Day (1 MGD = 1,121 acft/yr)
MSBR	Main Stem Balancing Reservoir
NEPA	National Environmental Policy Act
NTMWD	North Texas Municipal Water District
OCR	Off Channel Reservoir
DCPCMUD#1	Dallas County Park Cities Municipal Utilities District #1
RWP	Regional Water Plan
RRC	Red River Compact
RWP	Regional Water Plan
RWPG	Regional Water Planning Group
SRA	Sabine River Authority of Texas
SSWWTP	South Side Wastewater Treatment Plant
TCEQ	Texas Commission on Environmental Quality
TRA	Trinity River Authority
TRWD	Tarrant Regional Water District
TWDB	Texas Water Development Board
UNRMWA	Upper Neches River Municipal Water Authority
USACE	United States Army Corps of Engineers
USFWS	US Fish & Wildlife Service
UTRWD	Upper Trinity Regional Water District
WAM	Water Availability Model
WMS	Water Management Strategies
WQI	Water Quality Improvements
WTP / WWTP	Water Treatment Plant / Waste Water Treatment Plant

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Executive Summary

A. Introduction

A.1 Authorization, Objectives, and Scope

In August 2012, Dallas Water Utilities staff briefed the Dallas City Council concerning the need to update Dallas' previous long-range water supply plan. In September 2012, the City of Dallas retained HDR Engineering, Inc. (HDR) to develop the 2014 Dallas Long Range Water Supply Plan (2014 LRWSP). The development of the 2014 LRWSP was authorized under Contract No. 12-015E as approved at the September 26, 2012, Dallas City Council meeting as agenda item No. 41.

The last full review of Dallas' Long Range Water Supply plan was in 1989 with subsequent updates in 2000 and 2005. Since 1997, when Senate Bill 1 was passed, Dallas has participated in the state water planning process as overseen by the Texas Water Development Board (TWDB) through Dallas' participation in the Region C Regional Water Planning Group (Region C RWPG). The current Region C planning cycle schedule requires Dallas to provide a list of Recommended and Alternative Water Management Strategies (WMS) to the Region C RWPG in late 2014 / early 2015 for inclusion in the 2016 Region C Regional Water Plan (RWP).

The objectives of the 2014 LRWSP are to:

- Update population and water demand projections through 2070 considering revisions to Dallas' service area,
- Review current and future supply quantities from existing supplies through 2070,
- Analyze the impact of water conservation on demand,
- Compare and select water management strategies,
- Identify treatment, transmission and other infrastructure needs, and
- Recommend an implementation plan.

The scope of work for the development of the 2014 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,
- Evaluating, ranking and selecting water management strategies,
- Identifying infrastructure requirements and integration plans, and
- Developing implementation plans for selected strategies and preparation of a report.

The result of this effort is the development of the 2014 LRWSP for Dallas to meet the demands of its citizens and customers through 2070 and beyond.

A.2 Coordination with Related Studies

A number of related studies were underway during the development of the 2014 LRWSP and information from these studies was included in the 2014 LRWSP. These studies include:

- 2016 Region C Regional Water Plan – Region C Regional Water Planning Group
- Sulphur River Basin Wide Study – Sulphur River Basin Authority
- Upper Neches River Water Supply Study – Upper Neches River Municipal Water Authority
- Dallas Reclaimed Water Delivery System Feasibility Study – Bureau of Reclamation

A.3 Coordination with Customer Cities & Public Involvement

The study team conducted public and customer meetings during the planning process to solicit input from citizens, customer cities, and select stakeholders including environmental interests. The intent was to start a dialogue early on that provided the best information on which Dallas could build the plan. These meetings were documented and comments were addressed as appropriate throughout the planning study.

B. Planning Area

B.1 Recommended Planning Area

HDR, in cooperation with Dallas, is recommending that Dallas' planning area for the 2014 LRWSP be the same as the current service area and list of current customers. Dallas is not actively planning to meet the needs of any entity other than those that it currently serves within its service area. The 2014 LRWSP is focused on meeting the needs of a growing City of Dallas and the growth of its current customer cities. These customers are shown in Table ES-1 along with estimates of the current and 2070 demands on the Dallas system.

Table ES-1. Summary of Dallas Customers - Current and Projected 2070 Demands[1]

Source: Section 2.4, Table 2-1

Entity Name	Type of Supply	Contract Expiration Date	Approximate Current Demand on Dallas (MGD)	Projected Demand on Dallas in 2070 (MGD)
Addison	Treated	Jan. 6, 2042	5.4	10.4
Balch Springs [a]	Treated	Sep. 11, 2015	2.5	3.4
Carrollton	Treated	Jun. 29, 2043	21.0	20.4
Cedar Hill [b]	Treated	Sep. 26, 2044	9.3	15.2
Cockrell Hill	Treated	Feb. 22, 2044	0.4	1.0
Combine WSC [c]	Treated	Dec. 14, 2035	0.3	0.6
Coppell	Treated	Nov. 18, 2017	9.8	9.9
Dallas Retail Customers	Treated	N/A	245.6	359.3
Dallas County-Other	Treated	N/A	0.8	0.3
Denton	Untreated	Aug. 7, 2015	0.0	56.7
DeSoto	Treated	Aug. 24, 2043	8.4	12.2
DFW Airport	Treated	Oct. 23, 2015	2.6	4.1
Duncanville	Treated	Sep. 30, 2044	5.4	5.5
Ellis County WCID #1	Treated	Aug. 13, 2033	0.0	0.0
Farmers Branch	Treated	Aug. 1, 2040	8.1	10.4
Flower Mound	Treated	Jan. 21, 2017	7.6	7.8
Glenn Heights	Treated	Feb. 12, 2022	1.6	5.7
Grand Prairie	Treated	Jan. 6, 2042	19.6	30.0
Grapevine [d]	Untreated	Jun. 14, 2030	3.1	3.0
Hutchins [e]	Treated	Mar. 31, 2042	1.3	6.0
Irving	Treated	Jun. 30, 2033	15.3	4.5
Irving [f]	Treatment	Jun. 30, 2033	53.4	56.8
Lancaster	Treated	Nov. 11, 2041	6.8	13.5
Lewisville	Treated	Jun. 4, 2016	1.1	12.8
Lewisville [h]	Untreated	Dec. 17, 2016	18.0	18.0
Ovilla	Treated	Dec. 14, 2035	1.0	4.1
Red Oak	Treated	Aug. 13, 2033	0.1	1.7
Seagoville	Treated	Feb. 2, 2043	1.8	3.2
The Colony	Treated	Nov. 4, 2040	5.9	6.3
UTRWD [i]	Untreated	Feb. 12, 2022	34.2	54.0
Manufacturing Uses [j]	Treated	N/A	24.4	30.5
Mining Uses [j]	Treated	N/A	0.3	0.2
Steam-Electric Uses [j]	Untreated	Jan. 1, 2051 [k]	4.5	4.5
Irrigation Uses [j]	Untreated	Varies	2.6	2.6
Total			**468.8**	**717.8**

[a] Balch Springs was previously listed under the now dissolved Dallas County WCID #6. Dallas County WCID #6 was dissolved in 2014.

[b] Negotiated, but not yet approved as of Nov. 2, 1014.

[c] Combine WSC supplies the City of Combine.

[d] No contract maximum. Amount supplied is dependent on water availability. The contract estimates that 1.8 MGD will be used in any given year.

[e] Hutchins serves the community of Wilmer. Wilmer does not have a contract with Dallas, but Wilmer's demands are included as apart of Hutchins' demand.

[f] These values include the treated water demand for Irving and are not additive. Dallas has reserved 63 MGD on a peak day basis for treatment of Irving water (37.1 MGD on an average day). In addition, Dallas may commit up to 14 MGD of additional treatment capacity if deemed available.

[h] There is no contract maximum for the untreated water. Amount supplied is dependent on water availability. The contract estimates that approximately 20.6 MGD (23,094 acft) would be needed in 2010, the last year for which a projection was available.

[i] Although there is no set maximum to the contract, the amount supplied under the contract is dependent on certain service arrangements. It was originally projected that UTRWD would need about 39.1 MGD (43,825 acft) of water from Dallas in 2020. Dallas serves 10 MGD plus the following cities through UTRWD: Argyle WSC, Carrollton, Coppell, Denton (including Corinth and Lake Cities MUA), Flower Mound, Highland Village, and Lewisville.

[j] County aggregated demands from the 2016 Region C RWP.

[k] Luminant contract.

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[1] Dallas currently holds a contract with the North Texas Municipal Water District (NTMWD) for 60 MGD that is not shown on Table ES-1. The contract is for untreated water and will expire on 4/23/2016 (a 3-year contact). This contract is considered a temporary demand on the Dallas system, due to the extreme drought being experienced by NTMWD, and not a demand that Dallas plans to meet long-term.

C. Population

C.1 Updated Population Projections

As part of the 2016 Region C Regional Water Planning process, the Texas Water Development Board (TWDB) developed new population projections for each of the entities in Region C, including the City of Dallas and each of its customers. Population projections for the City of Dallas and its customer cities are summarized in Figure ES-1 and Table ES-2. In 2020, the population of Dallas and its customer cities is projected to be 3,047,046, while the City of Dallas population is projected to be 1,242,135 (or 40.6 percent of the total area population). In 2070, the total population of Dallas and its customer cities is projected to be 5,335,956, while the City of Dallas population is projected to be 1,905,498 (or 35.7 percent of the total area population). Note that Dallas does not serve the entire population of every customer city and that the values presented represent the planning area population, not the Dallas service area population.

Figure ES-1. Population Projections for City of Dallas and its Customer Cities

Source: Section 3.3, Figure 3-1

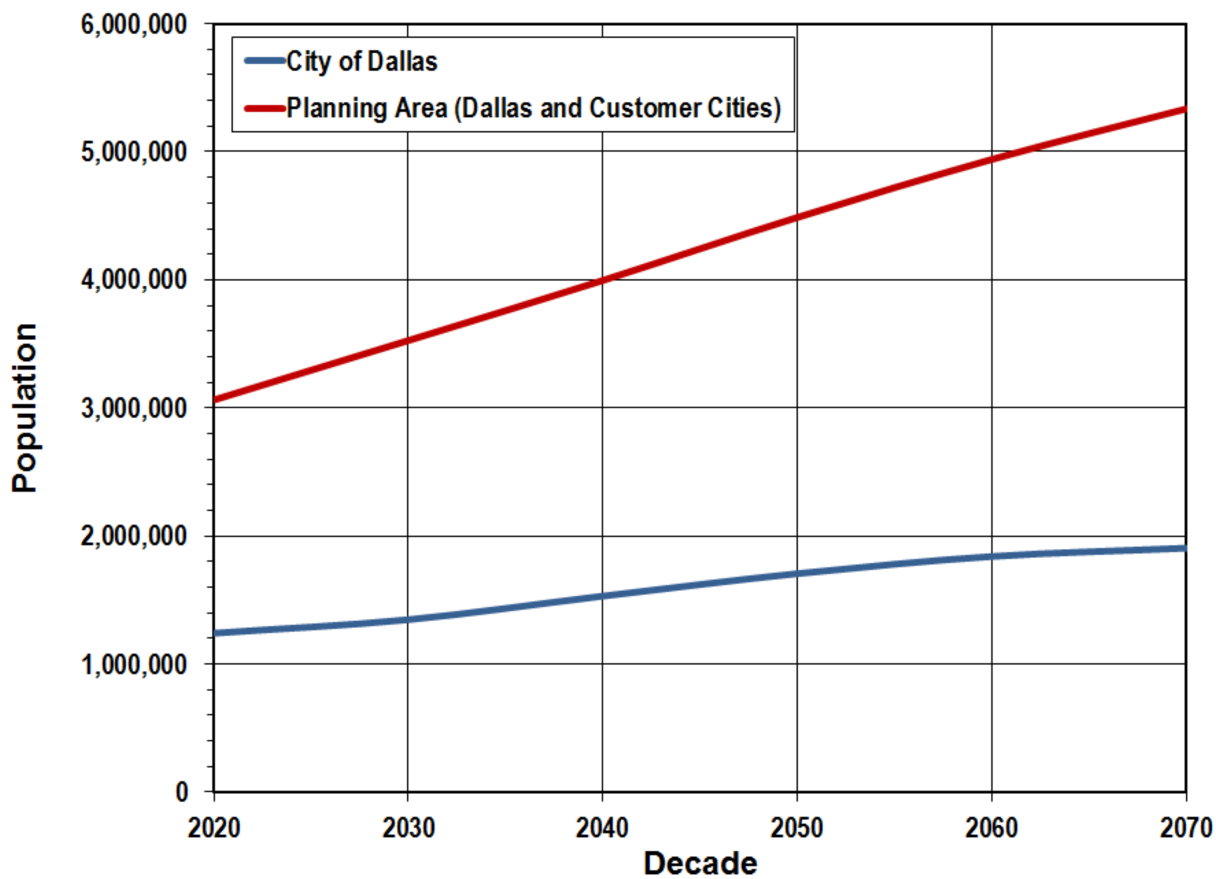


Table ES-2 Summary of Population Projections City of Dallas and its Customer Cities

table units: number of people

Source: Section 3.3, Table 3-1

Entity	2020	2030	2040	2050	2060	2070
City of Dallas	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498
Customer Cities	1,820,739	2,179,474	2,464,242	2,781,101	3,100,019	3,430,458
Total Planning Area Population	**3,062,874**	**3,527,191**	**3,995,923**	**4,488,158**	**4,941,083**	**5,335,956**

Source: 2016 Region C data as of September 12, 2014.

D. Water Demand & Wastewater Flows

D.1 Water Demand Projections

The water demands for the 2014 LRWSP are consistent with those used for the 2016 Region C RWP as of September 12, 2014. Table ES-3 shows that in 2020, total demand of Dallas and its customers is projected to be 468.8 million gallons per day (MGD). About 93.2 percent of the total demand comes from Dallas' retail and customer city demand. Other uses such as manufacturing, mining, irrigation and steam-electric power generation will make up the remaining 6.8 percent or 31.8 MGD. By 2070, total use is expected to be approximately 717.8 MGD with 94.7 percent of the demand coming from the municipal demand on the system. The non-municipal use types make up only 5.3 percent or 37.8 MGD of the total demand. Throughout this report Dallas' combined water supply system and associated demands is referred to as the Dallas Water Utilities System, DWU System, or system.

Figure ES-2 illustrates this information graphically. The City of Dallas projected demand in 2020 is 245.6 MGD or 52.4 percent of the total demand on the system. By 2070, the City of Dallas projected demand is 359.3 MGD or 50.1 percent of the total demand on the system.

Table ES-3. Water Demand Projections for the City of Dallas and its Customers

table units: MGD

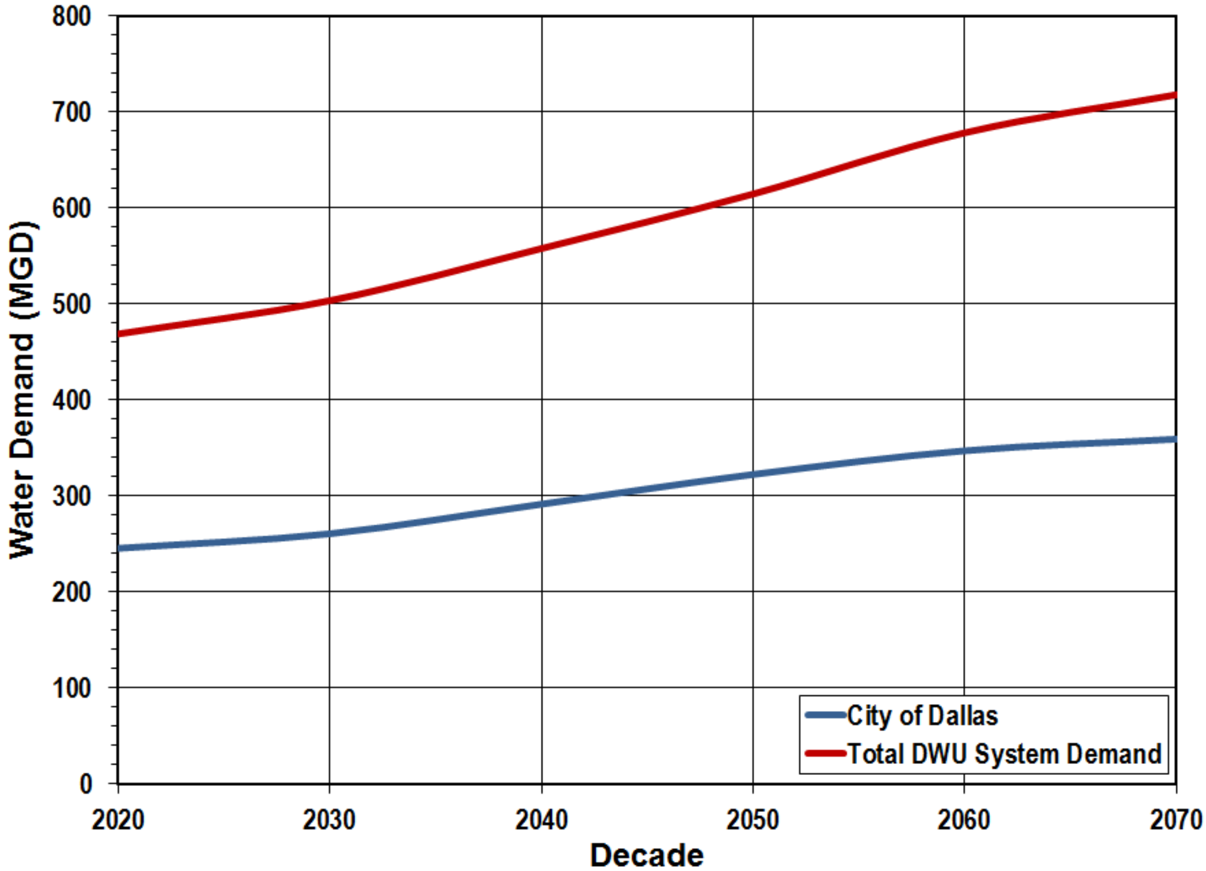
Source: Section 4.4, Table 4-3

DWU System	2020	2030	2040	2050	2060	2070
City of Dallas	245.6	260.8	291.6	322.5	347.2	359.3
Customer Cities	191.4	208.9	230.3	254.6	293.4	320.7
Non-Municipal Demand	31.8	33.8	35.8	37.4	37.6	37.8
Total Demand	**468.8**	**503.5**	**557.7**	**614.5**	**678.2**	**717.8**

Source: 2016 Region C data as of September 12, 2014.

Figure ES-2. Water Demand Projections for the City of Dallas and its Customers

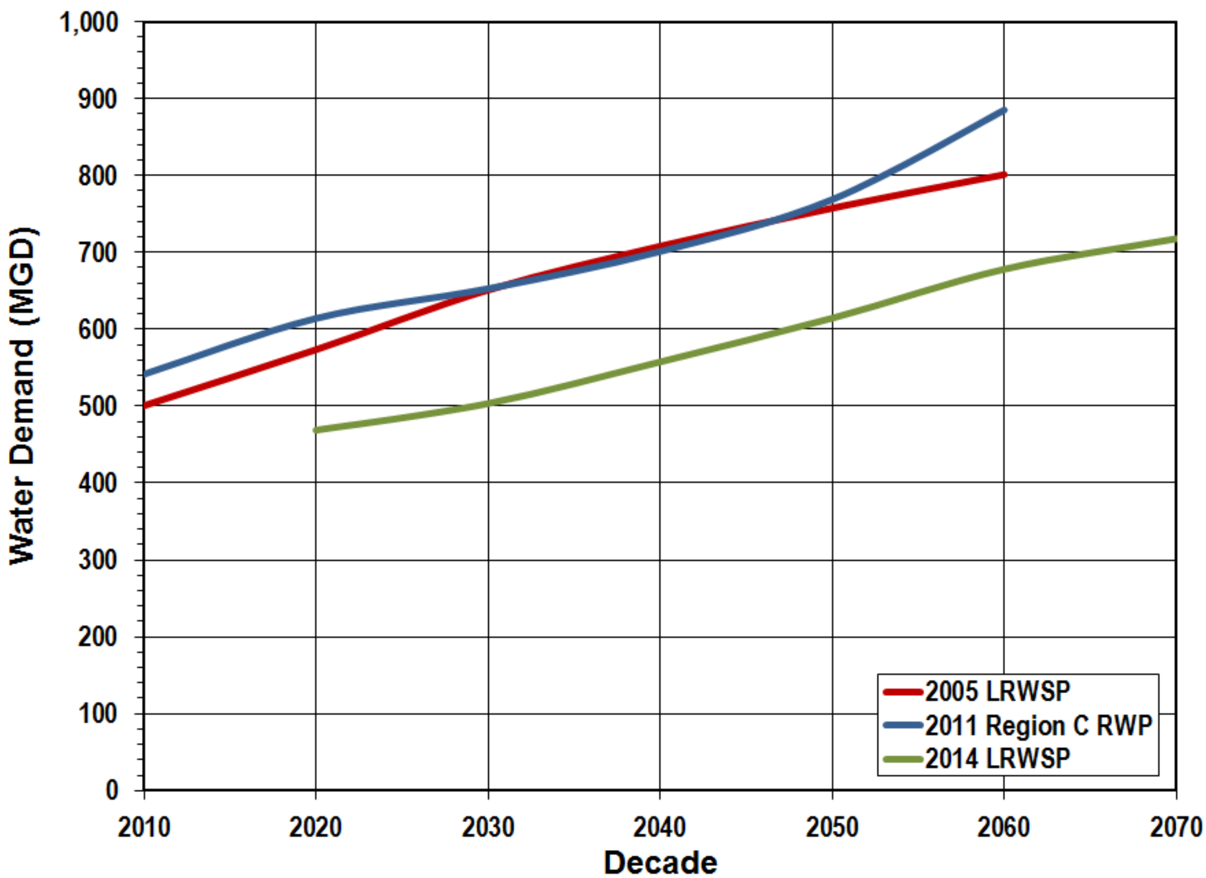
Source: Section 4.4, Figure 4-2



Water demand projections for the DWU system used in this 2014 LRWSP are compared with demands from both the 2005 Dallas LRWSP and the 2011 Region C RWP as shown in Figure ES-3. Water demands for both the 2005 LRWSP and the 2011 Region C RWP are similar. However, the water demand projections for the 2014 LRWSP are lower, because per capita use (gallons per capita per day or gpcd) values and population used in the 2014 LRWSP are substantially lower than the previous plans. In 2020, the 2014 LRWSP water demand projections are 145 MGD lower than the 2011 Region C RWP projections (a 23.6 percent decrease), in 2040, the 2014 LRWSP water demand projections are 143 MGD lower than the 2011 Region C RWP projections (a 20.4 percent decrease). Finally, in 2060, the 2014 LRWSP water demand projections are 207 MGD lower than the 2011 Region C RWP projections (a 23.4 percent decrease).

Figure ES-3. Comparison of Water Demand Projections –2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

Source: Section 4.4.2, Figure 4-4



D.1.1 Treated and Untreated Water Demand Projections

DWU provides both treated water and untreated water to its customers. Table ES-4 shows that the total treated water projected to be supplied by DWU to its retail customers, customer cities, and non-municipal users in 2020 is 408 MGD, increasing to 580 MGD by 2070 (a 42.2 percent increase). DWU provides untreated water supplies to Denton, Grapevine, Lewisville, the Upper Trinity Regional Water District (UTRWD) and various non-municipal customers including steam-electric power generation with projections for these entities shown in Table ES-5. Table ES-5 shows that the total untreated water projected to be supplied by DWU in 2020 is 61.1 MGD, increasing to 137.5 MGD by 2070 (a 125 percent increase).

Table ES-4. DWU Treated Water Demand Summary

table units: MGD

Source: Section 4.4.4, Table 4-12

DWU System	2020	2030	2040	2050	2060	2070
City of Dallas	245.6	260.8	291.6	322.5	347.2	359.3
Total Municipal Customer Treated Water Demand	136.1	144.0	157.2	168.8	178.2	189.0
Total Non-Municipal Treated Water Demand	26.0	28.0	30.0	31.6	31.8	32.0
Total Treated Water Demand	**407.7**	**432.8**	**478.8**	**522.9**	**557.2**	**580.3**

Source: 2016 Region C data as of September 12, 2014.

Table ES-5. DWU Untreated Water Demand Summary

table units: MGD

Source: Section 4.4.4, Table 4-13

Municipal Entity	2020	2030	2040	2050	2060	2070
Denton	0.0	1.9	8.8	20.3	40.3	56.7
Grapevine	3.1	3.4	3.4	3.3	3.1	3.0
Lewisville	18.0	18.0	18.0	18.0	18.0	18.0
UTRWD	34.2	41.6	42.9	44.2	53.8	54.0
Total Municipal Untreated Water Demand	**55.3**	**64.9**	**73.1**	**85.8**	**115.2**	**131.7**
Non-Municipal						
Collin County Irrigation	0.8	0.8	0.8	0.8	0.8	0.8
Dallas County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Dallas County Steam Electric (TXU)	4.5	4.5	4.5	4.5	4.5	4.5
Denton County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Rockwall County Irrigation	0.1	0.1	0.1	0.1	0.1	0.1
Total Non-Municipal Untreated Water Demand	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**
Total Untreated Water Demand	**61.1**	**70.7**	**78.9**	**91.6**	**121.0**	**137.5**

Source: 2016 Region C data as of September 12, 2014.

D.2 Historical Dallas Water Demand and the Impacts of Conservation

Dallas has achieved considerable savings in water demand by lower per capita use since conservation efforts began in earnest in the early 2000's. Dallas routinely experienced gpcd rates above 240 and as high as 280 in the late 1990's. Figure ES-4 illustrates these historical values and shows the impacts of Dallas' conservation efforts on reducing the gpcd values. The impact of conservation on water demand has been significant as shown by these key facts.

- Dallas saved through FY 2013 an estimated 250 billion gallons of water since 2001.
- Dallas gpcd has been reduced approximately 26 percent from FY01 to FY14.
- Dallas has been able to mitigate the impact of drought weather conditions on water supply.
- Since implementation of the Twice Weekly Watering Program in April 2012, water consumption is 5-6 percent lower.
- Non-watering days have 25 to 40 MGD less demand, an average of 8 percent less than watering days.
- Implementation of "time of day" watering has helped Dallas reduce peak demand on the system.

Figure ES-4. Recent Per Capita Water Consumption and Goals

Source: Section 4.5, Figure 4-5

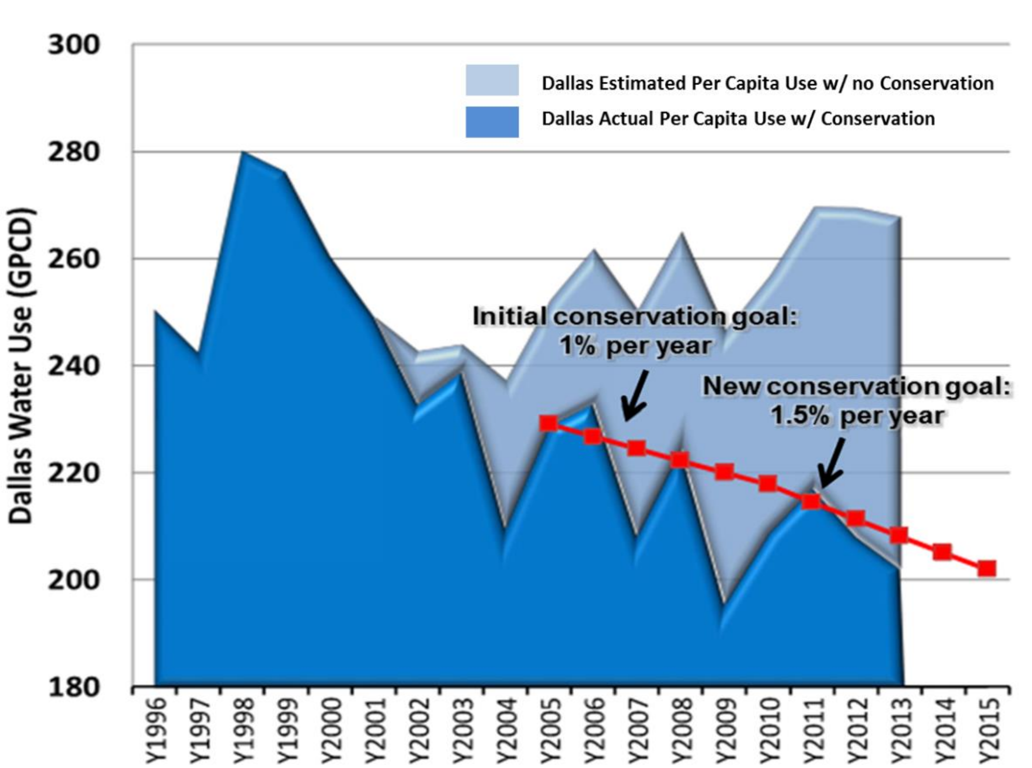


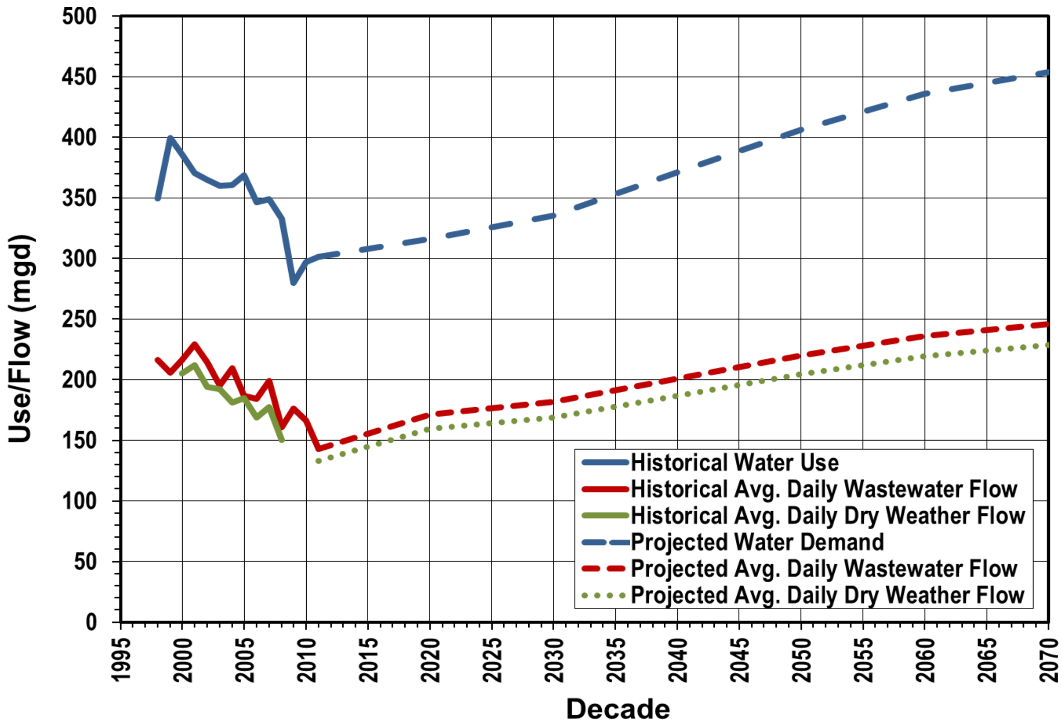
Figure Source: Dallas Water Utilities Water Conservation Program

D.3 Wastewater Effluent Projections

Projections of effluent for DWU wastewater customers were developed for the 2020 to 2070 timeframe for both the annual average wastewater flow (AAWF) and annual average dry-weather flow (ADWF). The AAWF accounts for both wet-weather and dry-weather periods while the ADWF is based on dry-weather periods only. Figure ES-5 shows historical and projected water use and wastewater flows projected as part of the 2014 LRWSP.

Figure ES-5. Historical and Projected Water Use and Wastewater Flows for DWU Wastewater Customers

Source: Section 4.6.4, Figure 4-9



E. Supplies

E.1 Existing Water Supplies

Dallas' water supply system is composed of seven supply reservoirs located in the Trinity, Sabine, and Neches river basins and run-of-river diversions from the Elm Fork of the Trinity River (Elm Fork). One of Dallas' reservoirs (Lake Palestine) is not currently connected to the Dallas system, but is planned to be connected through the Integrated Pipeline Project (IPL).

Dallas' supply system is divided into western and eastern subsystems to coincide with the demands in Dallas' treatment and distribution system. The western subsystem supplies Dallas' Elm Fork and Bachman water treatment plants (WTPs), and the eastern subsystem supplies the Eastside WTP. Figure ES-6 provides the location of Dallas' supply reservoirs, major raw water transmission pipelines, and three WTPs.

Figure ES-6. Location of Dallas Supply Reservoirs and Water Treatment Plants
Source: Section 5, Figure 5-1

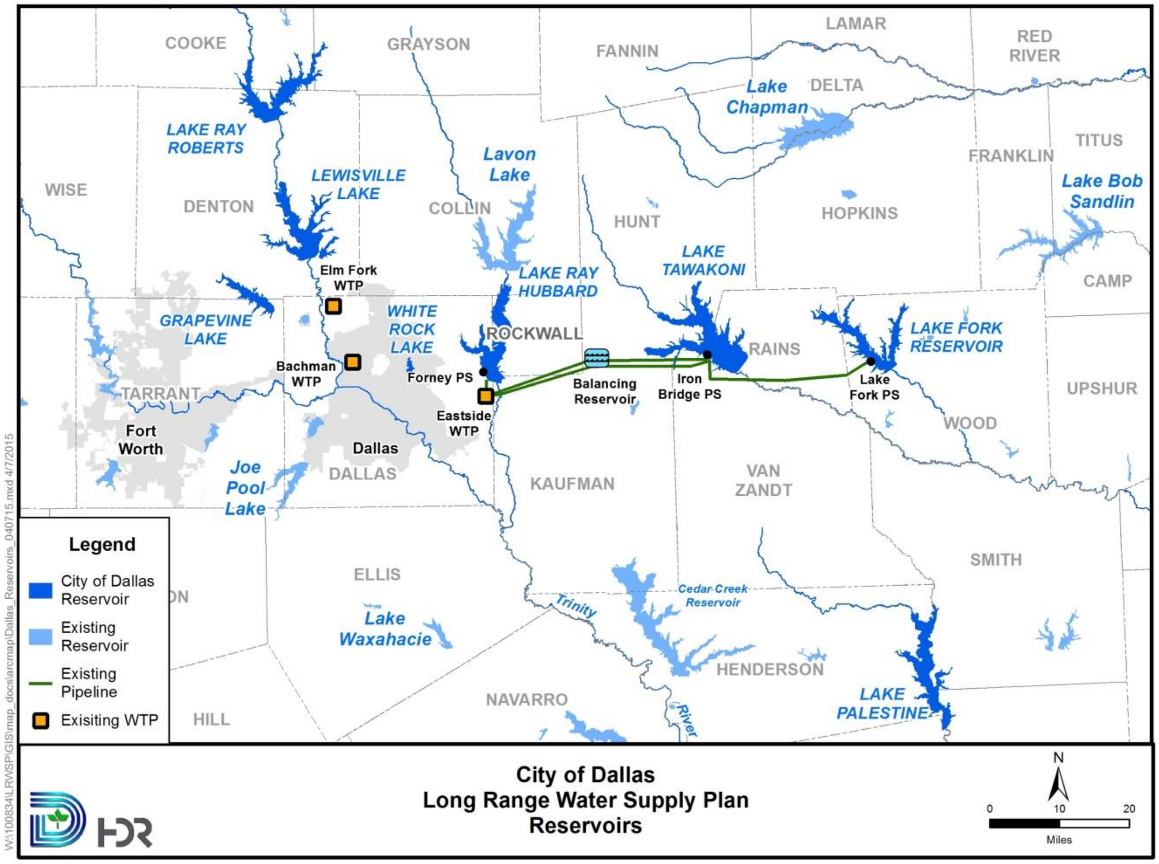


Table ES-6 provides a summary of Dallas' authorized diversions and contracts, current and future supplies available to Dallas, and supply losses resulting from both evaporation due to potential increases in temperature and sedimentation for Dallas' reservoirs through the 50 year period from 2020 to 2070 for the 1950's drought. The 2020 supply shown in Table ES-6 assumes a 2°F increase in high temperatures from historical averages and 2020 sediment conditions. The 2070 supply shown assumes a 7°F increase in high temperatures from historical averages and 2070 sediment conditions. It is estimated that Dallas will lose 77.8 MGD (87,100 acft/yr) or 13.0 percent of its reservoir supply from 2020 to 2070 from these two factors. Of this total supply loss, 60.7 MGD (68,000 acft/yr) or 78 percent is predicted to be a result of increases in evaporation and 17.1 MGD (19,100 acft/yr) or 22 percent is predicted to occur due to sedimentation. The 2070 firm yield available to Dallas is estimated to be about 563.3 MGD for both the connected and unconnected supplies.

Table ES-6. Summary of Dallas' Authorized Diversions, Contracts, and 2020 and 2070 Firm Yields Available to Dallas

Source: Section 5.4, Table 5-11

Reservoir	Dallas' Authorized Diversions and Contracts (MGD)	2020 Firm Yield Available to Dallas (MGD)	Projected Losses from Temperature Increases (MGD)	Projected Losses from Sedimentation (MGD)	2070 Firm Yield Available to Dallas (MGD)
Lake Grapevine	75.9	12.8	2.1	0.5	10.2
Elm Fork System [a]	1,074.0	162.0	26.0	6.0	130.0
Additional Elm Fork Return Flows	220.7 [d]	13.3	0.0	0.0	50.3
Lake Palestine [e]	102.0	102.0	0.0	0.0	102.0
Western Subsystem [f]	**1,472.6**	**290.1**	**28.1**	**6.5**	**292.5**
Lake Ray Hubbard	80.1	50.0	3.0	1.6	45.4
Lake Tawakoni	170.0	157.0	16.0	6.0	135.0
Lake Fork	117.0	107.0 [c]	13.6	3.0	90.4
Eastern Subsystem [b]	**367.1**	**314.0**	**32.6**	**10.6**	**270.8**
Total System	**1,839.7**	**604.1**	**60.7**	**17.1**	**563.3**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions made at Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought was assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD

[b] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

[c] The 107 MGD is the interbasin transfer amount available to Dallas from Lake Fork for use in the Trinity Basin. The authorization for Dallas is for a total of 117.7 MGD (131,860 acft/yr) with 107 MGD (120,000 acft/yr for use in the Trinity Basin.

[d] Total reuse diversion authorization contained in Dallas Permit 12468.

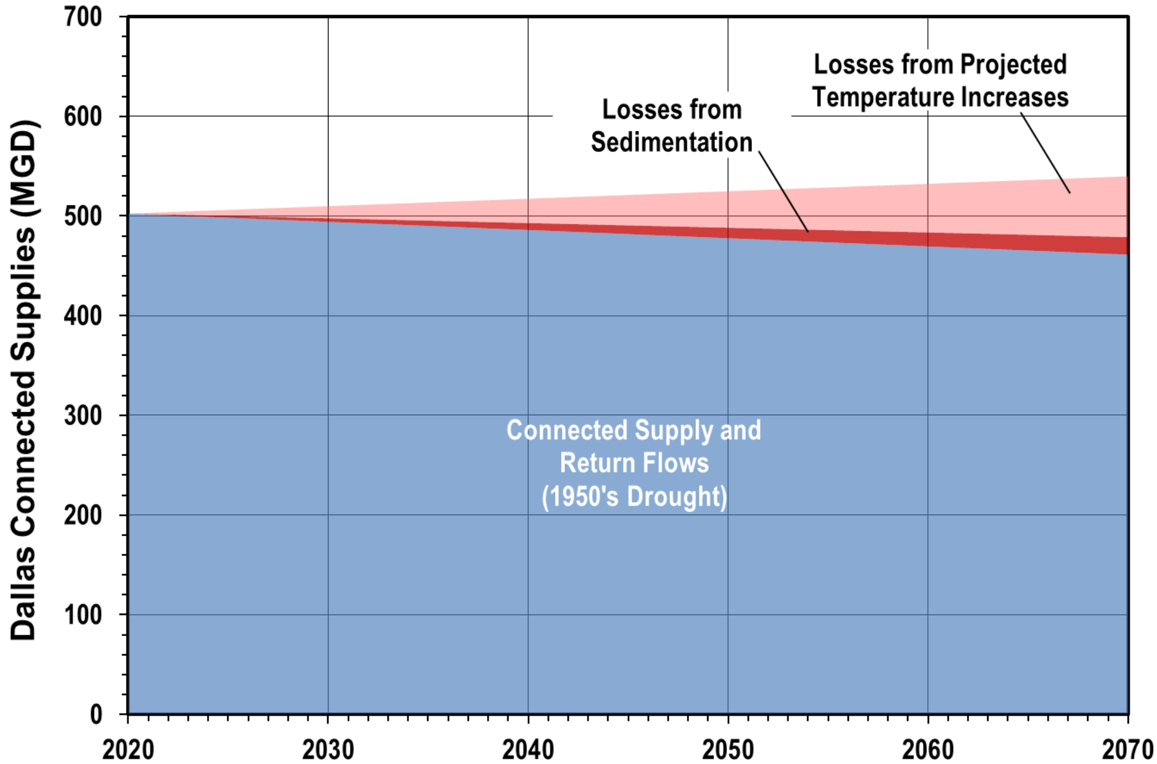
[e] Lake Palestine is not currently connected to the Dallas system, but is expected to be through the recommended IPL strategy. Note there are no evaporation or sediment losses shown because even though the reservoir experiences these losses, Dallas' portion remains whole.

[f] Return flow is expected to increase in the future as demand and subsequent discharges are also expected to increase.

Figure ES-7 illustrates Dallas' connected supplies and projected losses from 2020 to 2070. A portion of the losses will be offset by the projected increase in additional Elm Fork return flows available to Dallas. Table ES-7 provides a summary of Dallas' connected and unconnected (Lake Palestine) supplies by decade from 2020 to 2070.

Figure ES-7. Dallas Connected Supply considering Losses from Projected Temperature Increases and Sedimentation

Source: Section 5.4, Figure 5-4



F. Water Supply Needs & Recommended Plan

F.1 Water Supply Needs

Future water supply need is the difference between future demand and available supply. Dallas' future demands are projected to increase as a result of population growth, while Dallas' 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 supplies at some point in the future. The plan is to incrementally add additional supply to the Dallas system to overcome the deficit and provide a sufficient buffer.

Table ES-7. Summary of Dallas' Connected and Unconnected Supply by Decade

Units: MGD

Source: Section 5.4, Table 5-12

Reservoir	2020	2030	2040	2050	2060	2070
Lake Grapevine	12.8	12.3	11.8	11.2	10.7	10.2
Elm Fork System [a]	162	155	149	143	136	130
Additional Elm Fork Return Flows	13.3	16.4	20.8	29.2	41.8	50.3
Lake Ray Hubbard	50.0	49.1	48.1	47.3	46.3	45.4
Lake Tawakoni [b]	157	152	148	144	139	135
Lake Fork [b,c]	107	104	101	97.3	93.8	90.4
Total Connected Supply	**502.1**	**488.8**	**478.7**	**472.0**	**467.6**	**461.3**
Lake Palestine [d]	102	102	102	102	102	102
Total Connected and Unconnected Supply	**604.1**	**590.8**	**580.7**	**574.0**	**569.6**	**563.3**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions (CF-75 & 5414) from Frasier Dam.

[b] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

[c] The 107 (out of 117.1) MGD is the interbasin transfer amount available to Dallas from Lake Fork for use in the Trinity Basin.

[d] Dallas' contract with UNRMWA stipulates that Dallas' supply from Lake Palestine is limited to 53.73 percent of the yield up to a maximum of 102 MGD.

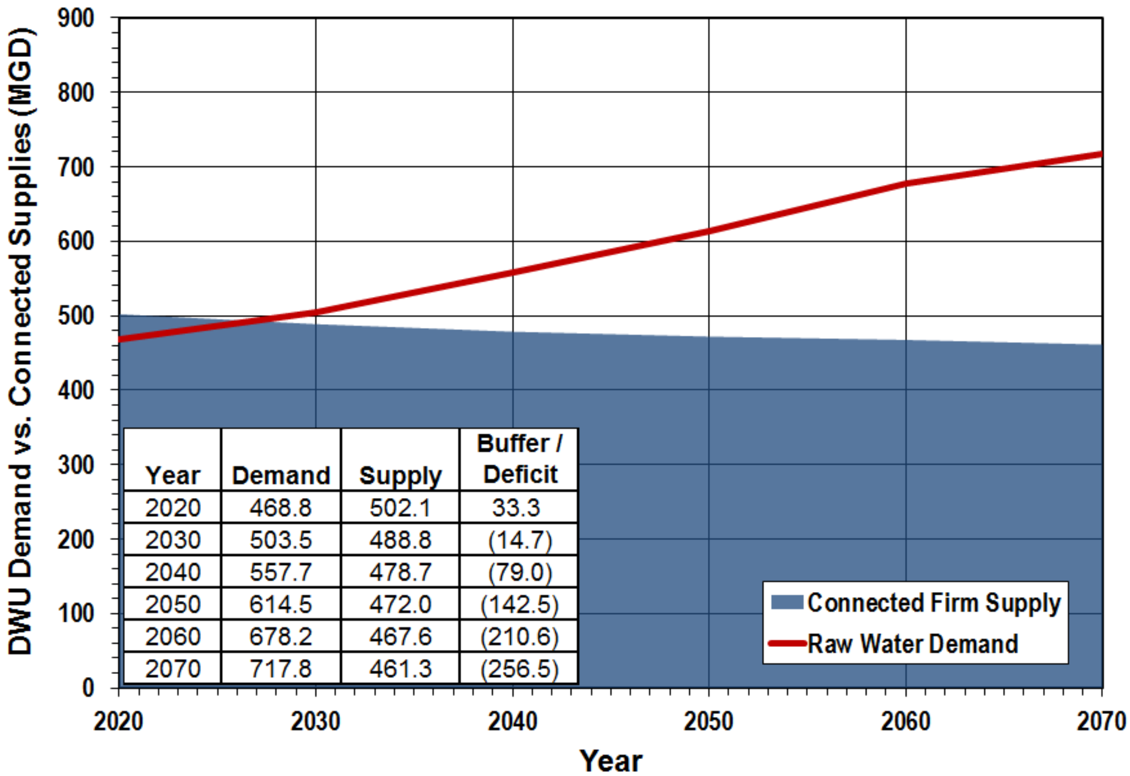
Figure ES-8 shows when demand is expected to overtake supply resulting in a supply deficit. This figure shows that in 2020 Dallas will have a total supply system buffer of 33 MGD and by 2070 will have a supply deficit of 256 MGD. Dallas' supply deficit begins to occur in about 2027 given the predicted growth in demand and the rate of declining supplies.

The DWU system as a whole is estimated to need additional supplies connected prior to 2027. However, when considering DWU's two subsystems separately, the need for additional supply occurs prior to 2020 for the western subsystem. DWU has the operational flexibility within its distribution system to shift supplies between the two subsystems to as much as a 40/60 percent split. DWU can use operational flexibility to temporarily shift up to about 60 percent of its demand on the WTPs to the eastern subsystem from the western subsystem and vice versa.

This flexibility allows Dallas to cover some of the early deficits shown for the western subsystem. The following list summarizes key findings from the 2014 LRWSP regarding Dallas' future water supply needs. This list highlights major findings that were considered during the process of selecting recommended strategies for Dallas to implement to meet the needs of the system for the next 50 years and beyond.

Figure ES-8.Comparison of Demand and Connected Supplies for DWU System

Source: Section 6.2, Figure 6-3



Year	Demand	Supply	Buffer / Deficit
2020	468.8	502.1	33.3
2030	503.5	488.8	(14.7)
2040	557.7	478.7	(79.0)
2050	614.5	472.0	(142.5)
2060	678.2	467.6	(210.6)
2070	717.8	461.3	(256.5)

Note: Figure shows that Dallas will have a supply deficit starting in about 2027.

- The Dallas water supply system is comprised of two subsystems.
  - The Dallas eastern supply subsystem includes Lake Ray Hubbard, Lake Tawakoni and Lake Fork all of which deliver to the Eastside WTP.
  - The Dallas western supply subsystem includes Lake Ray Roberts, Lake Lewisville, Lake Grapevine, and run of the river rights all of which deliver to the Bachman and Elm Fork Water Treatment Plants.
  - Dallas demands between the two subsystems are generally split 50/50 percent.
  - Dallas has operational flexibility to shift demands on the WTPs between the two subsystems up to a 60/40 percent split either way, which allows for near-term western subsystem deficits to be met from eastern subsystem supplies and treatment facilities.
- Dallas needs additional connected supply by about 2027 in order to maintain an overall system supply buffer. However, Dallas needs additional supply on the western subsystem sooner than the eastern subsystem.

Considering the above findings, Table ES-8 presents DWU demand, supply and need information for both the western and eastern subsystems and for the total system.

Table ES-8. Summary of Demands, Supplies and Needs for DWU Total System and Subsystems

Table units: MGD

Source: Section 6.2.3, Table 6-1

Supplies and Demands	2020	2030	2040	2050	2060	2070
Western Subsystem						
Lake Grapevine Supply	12.8	12.3	11.8	11.2	10.7	10.2
Elm Fork System Supply	162	155	149	143	136	130
Elm Fork Return Flows [a]	13.3	16.4	20.8	29.2	41.8	50.3
Western Subsystem Supply Total	188.1	183.7	181.6	183.4	188.5	190.5
50% Demand	234.4	251.8	278.9	307.3	339.1	358.9
Buffer / Deficit	(46.3)	(68.1)	(97.3)	(123.9)	(150.6)	(168.4)
Eastern Subsystem						
Lake Ray Hubbard Supply	50.0	49.1	48.1	47.3	46.3	45.4
Lake Tawakoni Supply	157	152	148	144	139	135
Lake Fork Supply	107	104	101	97.3	93.8	90.4
Eastern Subsystem Supply Total [b]	314	305.1	297.1	288.6	279.1	270.8
50% Demand	234.4	251.7	278.8	307.2	339.1	358.9
Buffer / Deficit	79.6	53.4	18.3	(18.6)	(60.0)	(88.1)
Total System						
Total Supply	**502.1**	**488.8**	**478.7**	**472**	**467.6**	**461.3**
Total Demand	**468.8**	**503.5**	**557.7**	**614.5**	**678.8**	**717.8**
Buffer / Deficit	**33.3**	**(14.7)**	**(79)**	**(142.5)**	**(210.6)**	**(256.5)**
Unconnected Supplies						
Lake Palestine (Western Subsystem)	102	102	102	102	102	102

[a] Includes increases in return flows available to Dallas in the Elm Fork System above the amount of return flows included in Dallas' RiverWare model that are already included in the yield numbers. This is 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 Dallas CIP for constructing in the near future and construction of this line is recommended in this plan.

F.2 Dallas Water Supply Plan

The 2014 LRWSP utilized a rigorous process to identify and evaluate strategies that could potentially meet Dallas' needs. These strategies were evaluated with respect to cost, supply quantity, potential environmental concerns, and overall feasibility. The goal of the process was to select strategies that provided the greatest benefits to Dallas while minimizing costs and environmental impacts.

The 2014 LRWSP strategy evaluation and ranking process resulted in a list of 14 preferred strategies. These 14 preferred strategies rose to the top of the rankings after over 300 strategies were identified from previous plans and studies as well as new strategies evaluated as part of the 2014 LRWSP. These preferred strategies served as the pool of strategies from which the recommended and alternative strategies were then selected. Table ES-9 provides a summary of the preferred strategies including the projected supply quantity and estimated unit cost associated with each.

Recommended strategies are strategies that Dallas will actively pursue and implement in the future to meet the needs identified in the 2014 LRWSP. The recommended water supply strategies are listed in Table ES-10 along with projected supply, total project cost and unit cost. **This table shows that the total combined project cost for the 2014 Dallas LRWSP is $2.452 billion dollars**, or on a unit cost basis taking into account amortization (5.5 percent for 30 years) $1.24 per 1,000 gallons. Figure ES-9 compares the type of recommended strategies that Dallas will be pursuing. This figure shows that 48 percent of Dallas' developed supply is expected to come from additional conservation and indirect reuse with another 27 percent coming from the connection to Lake Palestine. Only 25 percent is expected to come from the development of new surface water sources such as the Neches and Columbia strategies. Figure ES-10 shows the location of these recommended strategies in comparison to Dallas' existing water supply sources.

Table ES-9. Preferred Strategies – Summary of Projected Supply and Unit Cost

Source: Section 6.3.2, Table 6-2

2014 LRWSP Report Section	Strategy Name	Projected Supply (MGD)	Unit Cost ($/1,000 gal)
7.2	Additional Conservation (Dallas)	46.4	$0.38
7.3	Indirect Reuse – Main Stem Pump Station (NTMWD swap agreement)	31.1	$0.25
7.4	Indirect Reuse – Main Stem Balancing Reservoir	102	$1.74
7.5	Connect Lake Palestine	102	-
	IPL Part 1 – Connection to Lake Palestine [a]	-	$2.31
	IPL Part 2 – Connection to Bachman WTP [a]	-	$0.49
7.8	Direct Reuse – Alternative 1	2.23	$2.24
7.9	Carrizo Wilcox Groundwater (Alternative 2)	26.7	$1.80
7.6	Neches Run-of-River	42.2	$1.88
7.7	Lake Columbia	50.0	$1.78
7.10	Sabine – Conjunctive Use (OCR and groundwater)	93.0	$2.27
7.11	Red River OCR	102	$2.27
7.12	Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5) [b]	102	$2.28
7.13	Toledo Bend Reservoir	179	$3.14
7.14	Lake Texoma Desalination	130	$3.54

[a] Note that there are two components to the IPL strategy and that both are required to be implemented for Dallas to receive the additional supply of 102 MGD. The unit costs shown here include Dallas' portion of each project necessary to deliver water to the Dallas system.

[b] At the time of the Dallas City Council adoption of the recommended strategies the draft Sulphur Basin Wide Study identified reservoir elevations to determine yield and cost. Additional studies will be necessary to identify specific project elevations / configurations.

Table ES-10. Recommended Strategies for Dallas

Source: Section 6.3.2, Table 6-3

Recommended Strategies	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Additional Conservation	46.4	$51.7 [a]	$0.38
Indirect Reuse Implementation - Main Stem Pump Station – NTMWD Swap Agreement	31.1	$25.9 [b]	$0.25
Indirect Reuse Implementation - Main Stem Balancing Reservoir	102	$675	$1.74
Connect Lake Palestine	102 [c]	-	-
IPL Part 1 – Connection to Lake Palestine [c]	-	$939	$2.31
IPL Part 2 – Connection to Bachman WTP [c]	-	$244	$0.49
Neches Run-of-River	42.2	$227	$1.88
Lake Columbia	50.0	$289	$1.78
Totals	**373.7**	**$2,451.6**	**$1.24 [d]**

[a] Equivalent total project cost based on net present value analysis for the 50-year planning horizon. See Section 7.6.2 for detail.

[b] Represents Dallas' portion of the total project cost, see Section 7.3 for more details.

[c] The IPL project requires both the following projects to provide 102 MGD of supply to the Dallas system.

[d] This value is calculated by amortizing the total project cost at 5.5% for 30 years and dividing by projected supply in 1,000 gallons.

Figure ES-9. Comparison of Recommended Strategies by Type

Source: Section 6.3.2, Figure 6-6

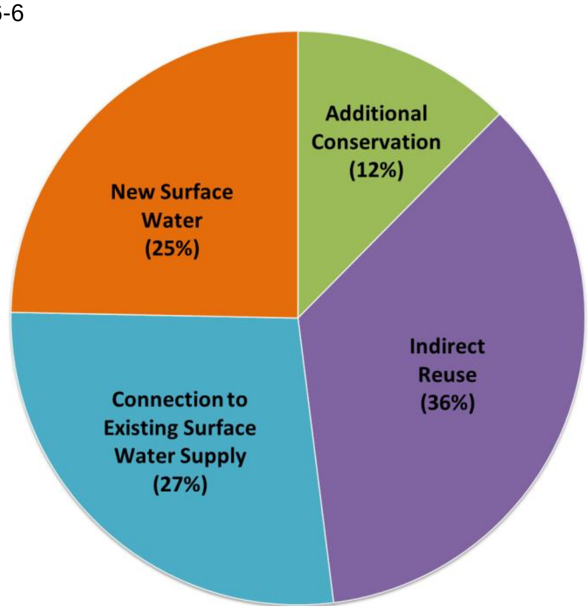
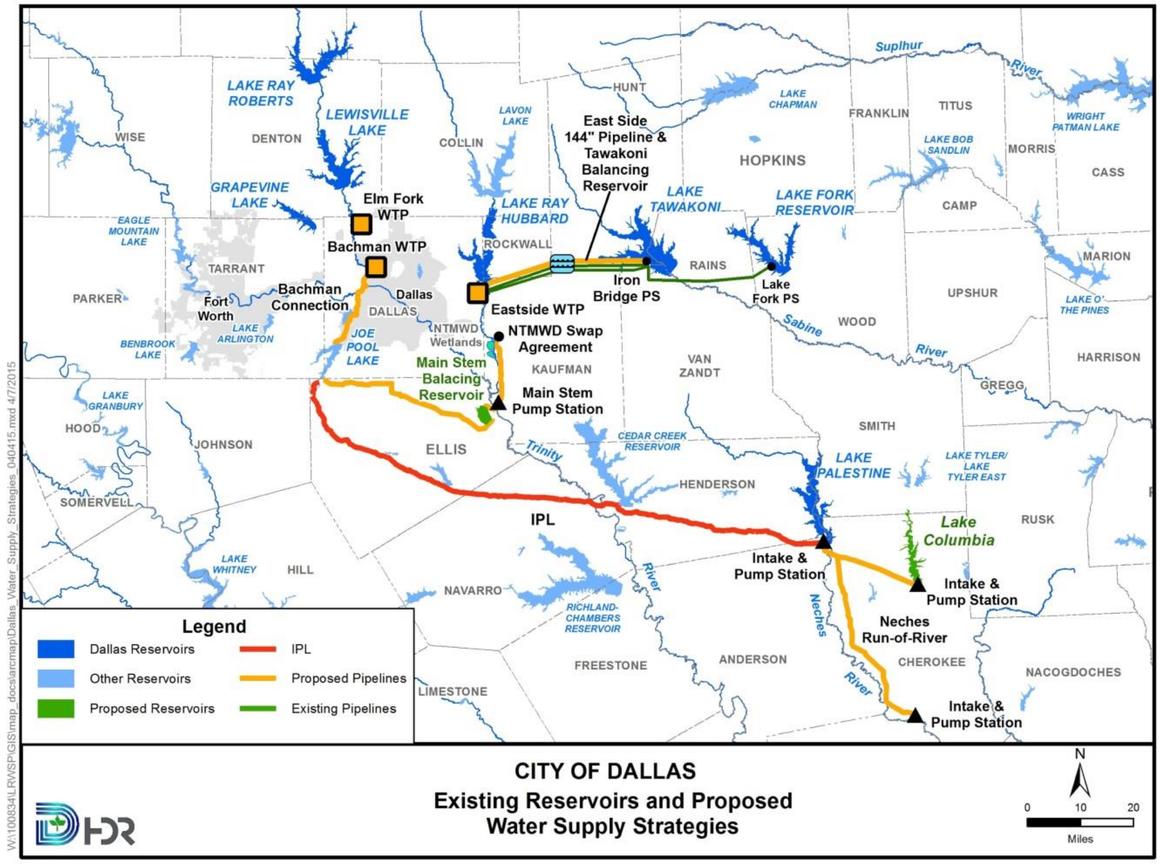


Figure ES-10. Dallas Water Supply System showing Recommended Strategies

Source: Section 6.3.2, Figure 6-7



* Note: IPL is a joint project between Dallas and TRWD. The IPL project shown on this map does not include segments that are 100% TRWD capacity.

The 2014 LRWSP includes a group of alternative strategies that were also identified from the list of preferred strategies. Alternative strategies are strategies that could be developed in the event one or more of the recommended strategies encountered an implementation obstacle that could not be overcome. It is recommended that Dallas continue to evaluate these strategies. The list of alternative strategies is shown in Table ES-11. Figure ES-11 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.

Table ES-11. Alternative Strategies for Dallas

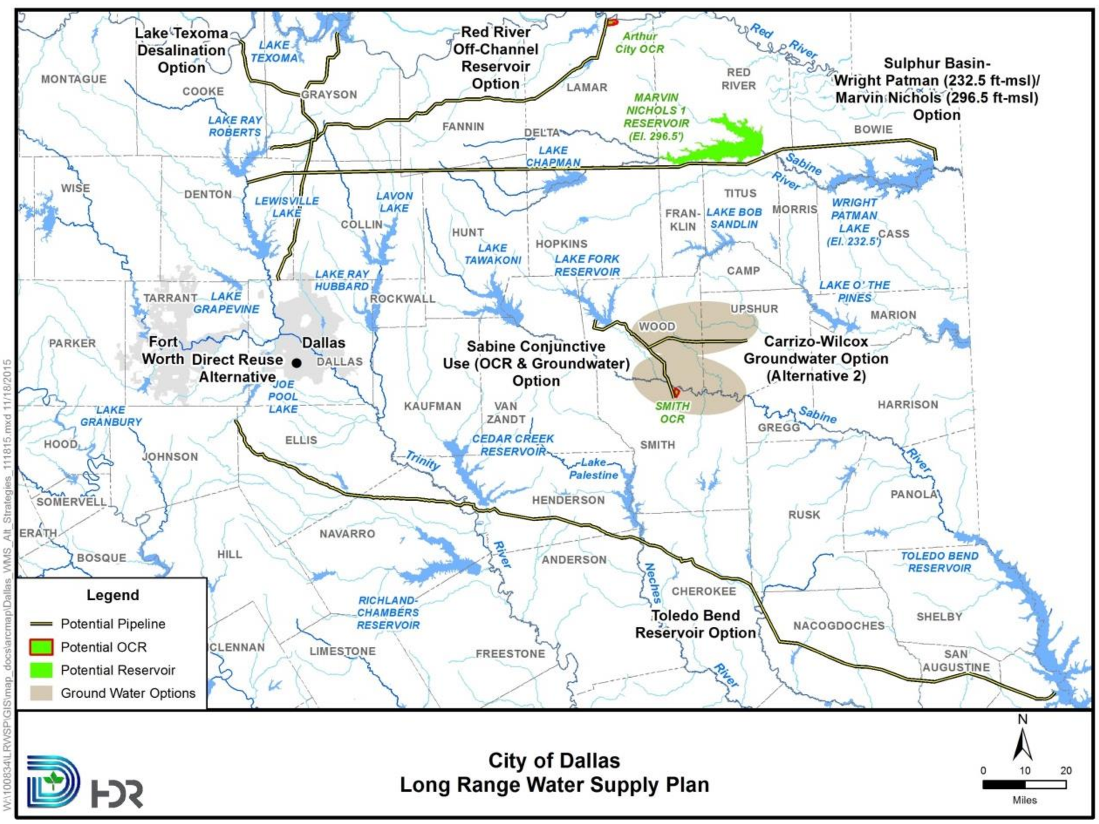
Source: Section 6.3.3, Table 6-4

Alternative Strategies	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Direct Reuse – Alternative 1	2.23	$27.4	$2.43
Carrizo Wilcox Groundwater (Alternative 2)	26.7	$161	$1.80
Sabine – Conjunctive Use (OCR and groundwater)	93.0	$796	$2.27
Red River OCR	102	$853	$2.27
Sulphur Basin Project - Wright Patman (232.5) / Marvin Nichols (296.5)	102	$1,003	$2.28
Toledo Bend Reservoir	179	$2,290	$3.14
Lake Texoma Desalination	130	$1,382	$3.54

[1] Specific water surface elevations for Wright Patman and Marvin Nichols were selected from the draft "Sulphur River Basin Wide Feasibility Study Final Cost Rollup Report" for costing purposes only. Additional studies will be necessary to finalize water surface elevations and project configurations.

Figure ES-11. Alternative Strategies for Dallas

Source: Section 6.3.3, Figure 6-8



F.3 Implementation Timeline

Once the recommended strategies were selected, it was necessary to determine the implementation schedule for these projects. Table ES-12 summarizes the needs for Dallas by decade and shows the recommended decade of implementation for each strategy. Note that strategies are not selected to just meet the needs of Dallas, zeroing out the deficit. The goal is to provide a supply buffer as shown on the table to help ensure that supplies are sufficient in the event a project is delayed or a worse drought than the drought of record were to occur. This information is presented graphically in Figure ES-12.

Table ES-12. Dallas Strategy Implementation Timeline

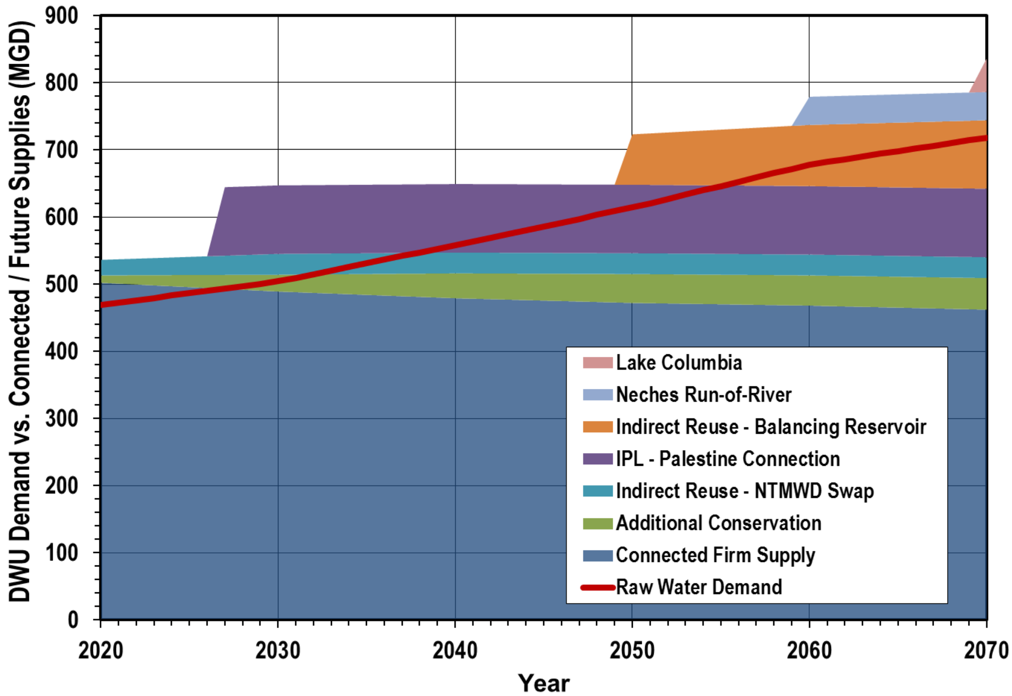
Table units: MGD

Source: Section 6.4, Table 6-5

Demand / Supply / Strategy	2020	2030	2040	2050	2060	2070
Current System						
Projected Raw Water Demand	468.8	503.5	557.7	614.5	678.8	717.8
Available Connected Supply	502.1	488.8	478.7	472	467.6	461.3
Buffer / Deficit	33.3	(14.7)	(79)	(142.5)	(210.6)	(256.5)
Recommended Water Management Strategies						
Additional Conservation	10.9	24.6	36.3	42.2	44.9	46.4
Indirect Reuse Implementation						
Main Stem Pump Station – NTMWD Swap Agreement	23.1	27.5	31.1	31.1	31.1	31.1
Main Stem Balancing Reservoir	-	-	-	75	90	102
Connect Lake Palestine	-	102	102	102	102	102
IPL Part 1 – Connection to Lake Palestine	-	-	-	-	-	-
IPL Part 2 – Connection to Bachman WTP						
Neches Run-of-River	-	-	-	-	42.2	42.2
Lake Columbia	-	-	-	-	-	50
Total Future System						
Supply from Recommended Strategies	**34**	**154.1**	**169.4**	**250.3**	**310.2**	**373.7**
Total Supplies	**536.1**	**642.9**	**648.1**	**722.3**	**777.8**	**835**
Buffer / Deficit	**67.3**	**139.4**	**90.4**	**107.8**	**99**	**117.2**
Percent Buffer of Total Supplies	**12.6%**	**21.7%**	**13.9%**	**14.9%**	**12.7%**	**14.0%**

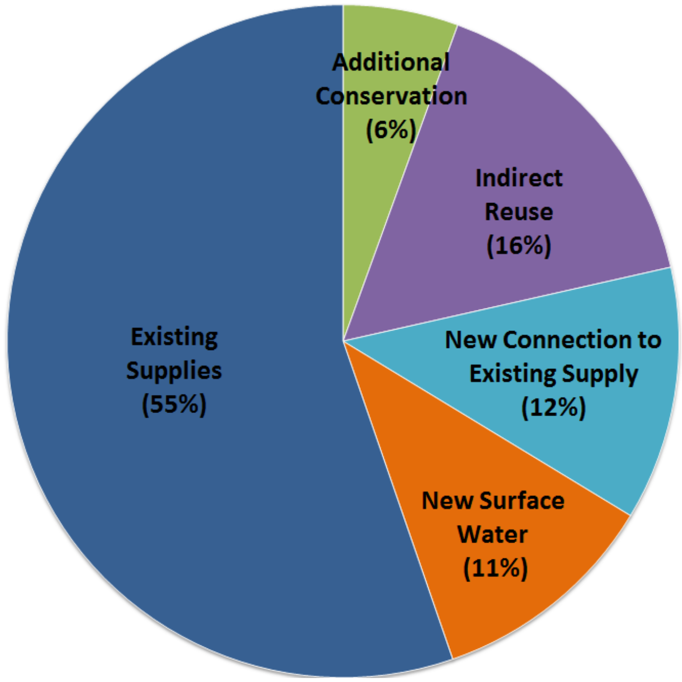
Figure ES-12. Recommended Strategy Implementation Timeline for Total DWU System (comparing Demands and Supplies)

Source: Section 6.4, Figure 6-9



The recommended water management strategies rely heavily on conservation, reuse, existing supplies, and partnering with other water supply entities. Figure ES-13 provides a comparison of the types of sources expected to be in Dallas' water portfolio in 2070. Fifty-five (55) percent of Dallas' supply in 2070 is expected to come from the sources that Dallas is currently utilizing today, namely its existing water supply reservoirs. Thirty-four (34) percent of its future portfolio will rely on additional conservation, indirect reuse, and connecting to sources that are untapped today (Lake Palestine). Only 11 percent is expected to come from new surface water supplies. These strategies have development challenges and overall risks that will need to be overcome through the implementation process. The 2014 LRWSP provides implementation steps for Dallas to follow to achieve the desired goal of implementing these projects in time to meet the anticipated growth.

Figure ES-13. Comparison of 2070 Connected Supply and Recommended Strategies by Type



As the development of new supplies becomes more challenging from a cost and permitting perspective, more consideration should be given to maximizing the potential for a regional water supply system for north Texas that includes Dallas and many, if not all of the other major water providers in the area including: NTMWD, TRWD, UTRWD, TRA, and others. DWU should consider discussing with all major water providers in the North Texas Metroplex area interest in a study to evaluate the benefits and problems of operating all or portions of the region's water supply sources as a single system or combined subsystems, instead of multiple separate systems. The goal would be to identify opportunities where the whole is greater than the sum of the parts where through system operation of different systems additional supply, resiliency, or various economies could be achieved.

G. Water Treatment Plant and Raw Water Conveyance System Capacity Needs

G.1 Water Treatment Plant Capacities

Dallas currently operates three large surface water treatment plants (WTPs) to serve its growing customer base. The Bachman and Elm Fork WTPs are part of the Western Supply Subsystem and the Eastside WTP is part of the Eastern Supply Subsystem. Table ES-13 lists the rated production and reliable production capacities for each of Dallas' WTPs. Several projects are currently planned or underway to achieve a reliable production capacity equal to that of the rated production capacity. These projects include treatment plant improvements as well as improvements to the pumping and distribution system to alleviate hydraulic bottlenecks in the system. The rated production capacity is defined as the maximum treated water production when accounting for internal plant water use and waste streams. The reliable production capacity is the capacity at which each plant is considered operable for an extended period of time without limitation or increased risk of treatment or distribution issues.

Table ES-13. Water Treatment Plant Rated and Reliable Production Capacities

LRWSP Section 8.2.3. Table 8-3

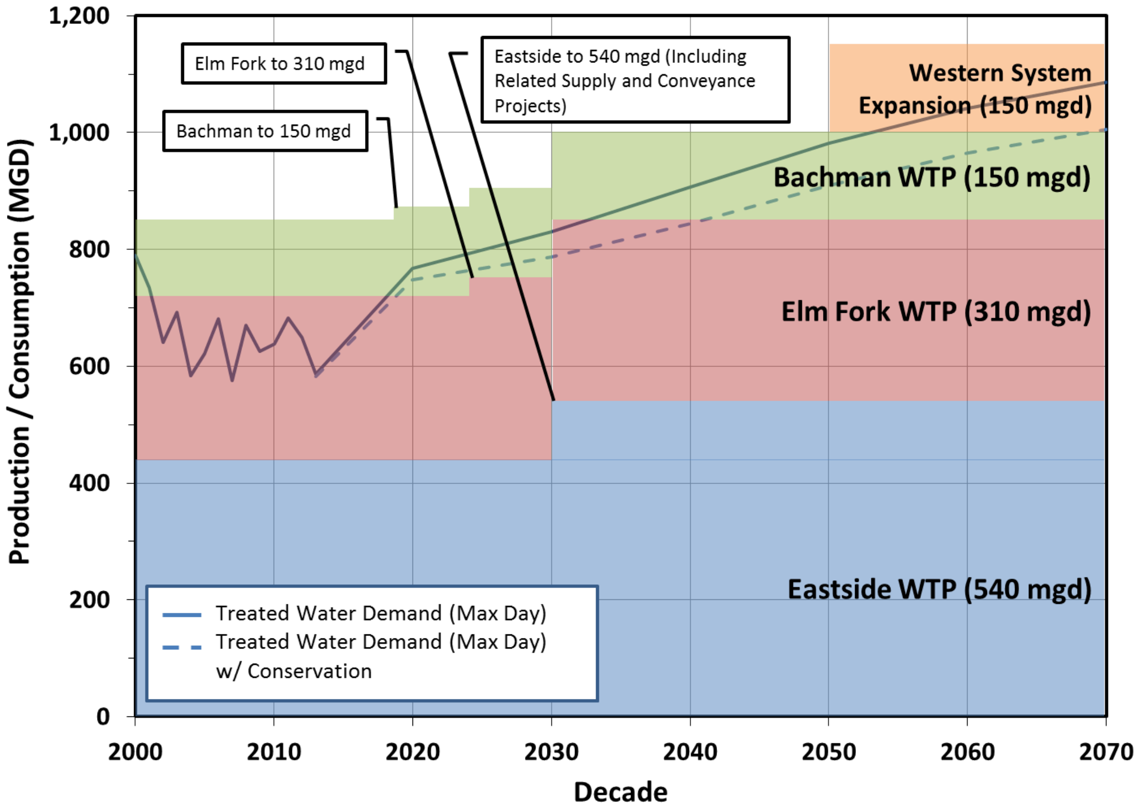
Water Treatment Plant	Rated Production Capacity (MGD)	Reliable Production Capacity (MGD) [a]	High Service Pumping Capacity (MGD)	Minimum Limiting Capacity (MGD)
Bachman	150	130	150	130
Elm Fork	310	280	310	280
Eastside	540	500	440	440
Total	**1,000**	**910**	**900**	**850**

[a] As discussed in Section 8, several projects are currently planned or underway to fully utilize Dallas' rated production capacity of the WTPs.

Figure ES-14 provides an overall, system-wide perspective on recommended improvements to the water treatment system. As shown, the resulting combined treatment capacity provides sufficient capacity on a system-wide basis with some flexibility. For example, if a treatment process train at one of the WTPs fails or requires shutdown during maximum day demand conditions and water can be moved between the Western and Eastern subsystems, some buffer is available to allow shutdown while minimizing the risk of depleting available treated water.

Figure ES-14. Combined Treatment Capacity vs. Projected Max Day Demands

Source: Section 8.3.3, Figure 8-9



G.2 Raw Water Conveyance Capacities

Table ES-14 provides a summary of the existing raw water pumping (or pipeline) capacities for the Western and Eastern Raw Water Supply Subsystems relative to the 2070 average day supply. Based on a review of Dallas' average and peak day demands, for planning purposes the ratio of pumping (or pipeline) capacity (whichever is limiting) to supply should equal or exceed 1.71 for that component of the system to meet its share of peak day demands.

Table ES-14. Raw Water Conveyance System Capacities Compared to 2070 Supplies

Source: Section 8.4.2, Table 8-4

System Component	Pumping Capacity (MGD) [a]	Pipeline Capacity (MGD)	2070 Average Day Supply [b] (MGD)	Ratio of Capacity to 2070 Supply [c]
Western Subsystem Raw Water Conveyance				
Elm Fork WTP Supply and Raw Water Pumping	338	> 338	123.8	2.7
Bachman WTP Supply and Raw Water Pumping	160	> 160	66.7	2.4
Western Subsystem Total	**498**	**> 498**	**190.5**	**2.6**
Eastern Subsystem Raw Water Conveyance				
Lake Fork, Lake Fork Pump Station, and 108-inch Pipeline to the Tawakoni Interconnect	212	215	90.4	2.3
Lake Tawakoni, Iron Bridge Pump Station, and 72-inch / 84-inch Pipelines to Tawakoni Balancing Reservoir and on to Eastside WTP	230	215[d]	226[e]	0.95 [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, 2070 sediment conditions and 7 degree F increase in historical temperature.

[c] Should be greater than 1.71 to meet peak day requirements as discussed in Section 8.4.2. 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] Dallas currently has an amendment pending at TCEQ 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.

For the Western Raw Water Conveyance Subsystem, the ratio of current capacity to 2070 supply of 2.6 exceeds the recommended ratio of 1.71 to meet peak day requirements. However the capacity of the Eastern Raw Water Conveyance Subsystem needs to be increased to meet future demands by constructing the 144” raw water line from Tawakoni to Eastside as shown in Table ES-15, and discussed in more detail in Section 8.4.2.

Table ES-15 presents the infrastructure improvement programs associated with newly identified raw water supply and treatment capacity needs. The projects are categorized in terms of respective drivers based on:

Project Driver Definition

- G = growth / capacity driven
- R = regulatory / water quality driven
- M = maintenance / reliability driven

Table ES-15. Summary of Future Water Supply Strategies and Treatment Infrastructure Projects

Source: Section 8.7.2, Table 8-9

Project	Drivers	Start By [a]	Complete By [a]	Capital Cost [b]
Target Projects for Completion by 2020				
Elm Fork WTP *Pre-sedimentation Basin*	G / R	Q1 2015	Q3 2017	$30 M
Elm Fork WTP *Residuals Handling Improvements*	G / R / M	Q3 2015	Q2 2018	$95 M
Eastside WTP *Water Quality Improvements* [c]	G / R / M	Q4 2015	Q3 2018[d]	$75 M
72-inch Treated Water Pipeline *Bachman WTP to Elm Fork WTP*	G / R / M	Q4 2015	Q3 2018	$57 M
Elm Fork WTP *Pump Station 1*	R / M	Q1 2016	Q2 2018	$35 M
Main Stem Pump Station / Pipeline to NTMWD Wetlands	G	Q1 2017	Q1 2020	$18 M
2020 Target Projects Total				***$310 M***
Target Projects for Completion by 2025				
Iron Bridge Pump Station *Rehabilitation*	R / M	Q4 2019	Q1 2022	$47 M [e]
Eastside WTP *Residuals Basins and Sludge PS Improvements*	M	Q1 2018	Q1 2022	$95 M
Elm Fork WTP *Water Quality Improvements* [f]	G / R / M	Q4 2018	Q1 2024	$240 M
2025 Target Projects Total				***$382 M***
Target Projects for Completion by 2030				
IPL Project *Connect Lake Palestine*	G	On-going	Q1 2027	$1,097 M [g]
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to Eastside WTP*	G / M	Q1 2026	Q1 2030	$420 M

Table ES-15. Summary of Future Water Supply Strategies and Treatment Infrastructure Projects (Cont.)

Source: Section 8.7.2, Table 8-9

Project	Drivers	Start By [a]	Complete By [a]	Capital Cost [b]
Wintergreen Pump Station and Southwest Pipelines	G	Q1 2026	Q1 2030	$310 M
Tawakoni Balancing Reservoir Expansion	G / M	Q1 2027	Q1 2030	$66 M
Eastside WTP *Electrical Distribution System Improvements and Substation 3*	G / M	Q4 2027	Q1 2030	$18 M
Eastside WTP *Stage V Filters*	G / R	Q4 2027	Q1 2030	$40 M
2030 Target Projects Total				***$1,951 M***
Target Projects for Completion by 2035				
Stage 2 Spent Filter Backwash Treatment at WTPs	G / R	Q1 2031	Q1 2035	$112 M [h]
Target Projects for Completion by 2050				
Main Stem Balancing Reservoir (DWU) Pump Station / Pipeline	G	Q1 2040	Q1 2050	$434 M [i]
Western WTP Expansion	G	Q1 2046	Q1 2050	$405 M [j]
2050 Target Projects Total				***$839 M***
Target Projects for Completion by 2060				
Neches Run-of-the-River	G	Q1 2050	Q1 2060	$160 M
Target Projects for Completion by 2070				
Lake Columbia	G	Q1 2060	Q1 2070	$160 M
50-Year Target Projects Total				***$3,914 M***

[a] Start and finish of construction; based on an understanding of inter-relating projects and sequencing through discussions with DWU staff and WQI program components.

[b] Capital costs are for construction only and based on costs reflected in the Dallas 2014 CIP unless otherwise noted.

[c] Eastside WTP WQI projects remaining include the non-chlorinated backwash pump station, post-clearwell ammonia feed, chemical feed water softening, and engineered biofiltration chemical systems ($30M per 2014 CIP) and filter-to-waste / hydraulic improvements with media replacement ($45M per 2014 CIP); process conversion to biofiltration is on-going and sedimentation basin modifications were awarded for construction in 2014 and therefore are not shown.

[d] The Dallas 2014 CIP indicates filter-to-waste / hydraulic improvements with media replacement ($45M) in Fiscal Year 20-21; the change to GAC media is an additional optimization step for biofiltration and can be completed in parallel with other projects.

[e] Based on latest HDR Engineering, Inc. opinion of probable construction cost.

[f] Elm Fork WTP WQI includes rapid mix, flumes, east chemicals, biological filters, floc-sed basins, and west chemicals assumed as one project; costs based on recent understanding of projected WQI program costs

[g] Total Capital Cost includes Elm Fork expansion and transmission improvement costs .

[h] Based on $35M for Elm Fork WTP from previous DWU study; $17M for Bachman WTP and $60M for Eastside WTP based on capacity ratio relative to Elm Fork WTP.

[i] See Section 7-6: includes delivery to Joe Pool reservoir, but not to a Dallas treatment plant

[j] See Section 7-5.

H. Conclusions and Recommendations

H.1 Summary

Dallas initiated the 2014 LRWSP effort in 2012 with the goal of identifying, evaluating, and selecting water management strategies to meet future water supply needs for Dallas and its customers. Dallas has identified six (6) recommended water management strategies that meet this goal. These recommended strategies rely heavily on conservation and reuse supplemented by the development of new supplies by partnering with other water supply entities. The key findings and conclusions, recommendations, and next steps for Dallas to consider in the implementation of the 2014 LRWSP are summarized below.

H.2 Findings and Conclusions

Findings and conclusions from the analysis and evaluations performed during the development of the 2014 LRWSP include the following:

- Between 2020 and 2070 Dallas' existing supplies are expected to decrease from 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.
- Dallas' demands are split almost evenly between its eastern and western subsystems with needs appearing sooner on the west due to limitations of existing firm supplies.
- Additional raw water supply provided by Lake Palestine through the IPL project is needed by about 2027 to minimize the risk of water supply shortages during droughts.
- Combined reliable water treatment production capacity is currently about 850 MGD considering treatment and high service pumping limitations.
- Treated water peak day demands are expected to exceed Dallas' reliable water treatment capacity of 850 MGD (when considering reliable production capacity and high service pumping capacity) by about 2034, or in about 20 years.
- Addressing reliability concerns and expansion in the eastern subsystem by implementing previously planned projects will satisfy capacity needs and if completed prior to about 2030, could allow for the delay of a western subsystem WTP expansion.
- Implementation of the recommended strategies on the schedule provided in the 2014 LRWSP allows Dallas to keep about a 15 percent supply buffer over the estimated demands.
- Dallas should move forward on the recommendations provided in this section to begin implementing recommended strategies.

H.3 Recommendations

The following is a list of recommendations, or next steps, that Dallas should move forward with to implement the findings of the 2014 LRWSP. These recommendations are separated into three groups: additional studies, permitting, and strategy implementation, and infrastructure improvements.

H.3.1 Additional Studies

The following studies and activities were identified during the development of the 2014 LRWSP and are recommended for Dallas's consideration:

- Dallas should initiate a Main Stem Balancing Reservoir permitting and feasibility study that includes:
  - securing the water rights permit for the storage reservoir and amend Dallas' existing reuse permit instream flow requirements,
  - performing a reservoir site foundation (geotechnical) evaluation,
  - preparing a water quality evaluation of the reservoir,
  - performing a siting study for the main-stem balancing reservoir pump station considering bank stabilization, water level control and flooding issues;
  - 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 and TRWD should re-evaluate the planned 150 MGD capacity of the two Palestine to Cedar Creek segments of the IPL considering that the combined supply from the three recommended strategies could supply as much as 194 MGD [i.e. Lake Palestine (102 MGD), Neches Run-of-the-River (42 MGD) and Lake Columbia (50 MGD)]. Once the delivery capacity is finalized, Dallas and TRWD should proceed with the final design of the Palestine to Cedar Creek segment of the IPL. An evaluation of the shared segments of the IPL should be performed to identify what upgrades may be needed to deliver future additional supply through this pipeline.
- Dallas should initiate a follow-on study to the 2014 LRWSP that results in identifying critical infrastructure components and associated implementation phasing needed to fully integrate the recommended strategies that together will supply 296 MGD of new supply to Dallas' western subsystem. This includes supplies from Lake Palestine (102 MGD), the Main Stem Balancing Reservoir (102 MGD), Neches Run-of-the-River (42 MGD), and Lake Columbia (50 MGD). This study would consider alternative delivery routes considering a combination of pipelines and natural stream systems, potential use of Joe Pool Lake storage or other facilities for meeting balancing needs and water quality and blending issues. This study would consider and include:
  - Coordination with TRA and other stakeholders regarding the potential use of Joe Pool Lake as part of the delivery system for the IPL water considering water quality and blending issues.

  - Development of a Western Subsystem Water Treatment Master Plan which considers the implications of implementing the recommended water supply strategies and associated treatment plant and distribution system improvements.

- 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 chosen by Dallas as part of the 2014 LRWSP, 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.
- Partner with the ANRA on the permitting of Lake Columbia including the 404 permitting process and the amendment of ANRA's existing water right to include an interbasin transfer which would authorize Dallas' use of this water in the Trinity River Basin.
- Dallas should continue to pursue potential new customers for direct non-potable reuse.
- Dallas in cooperation with other regional partners should initiate a feasibility study of the Red River 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 with other regional partners for the conjunctive use of Carrizo-Wilcox groundwater and diversions of Sabine River water to an OCR.
- Dallas should discuss the potential interest with all major water providers in the North Texas Metroplex area to consider a study to evaluate the benefits and problems of operating all or portions of the region's water supply sources as a single system or subsystems, instead of multiple separate systems.

H.3.2 Permitting

Dallas should immediately proceed with several permitting efforts identified in the LRWSP given the complexity of the current regulatory and permitting system for water rights permits. Suggested permitting activities include:

- DWU should seek an amendment to the Lake Ray Roberts and Lewisville permits that allow for downstream diversion of the existing authorized diversion at the Main Stem Balancing Reservoir site. This would not be a request for new state water, but a request to move some of Dallas' existing diversion rights downstream.

- DWU should seek an amendment to the return flows permit to remove a portion of the 114,000 acft/yr instream flow restriction and have it replaced with the newly adopted Senate Bill 3 environmental flow standards for the Trinity River Basin.
- DWU should seek the required permit necessary for the Main Stem Balancing Reservoir. This could be a separate application or an amendment to the existing Dallas return flow permit.
- DWU should seek authorization to use the bed and banks of the East Fork and Main Stem of the Trinity River to transport water from Lake Ray Hubbard (and possibly the Tawakoni Pipeline) for subsequent diversion at the Main Stem Balancing Reservoir for use in the western subsystem to allow for greater flexibility in system operations.

H.3.3 Strategy Implementation & Infrastructure Improvement

Several recommendations from the 2014 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.
- Continue discussions with USACE on the required maintenance for USACE owned Dallas supply reservoirs. Implement a long-term maintenance plan to provide for continued use of these resources.
- Continue to coordinate with NTMWD on the implementation of Main Stem Pump Station swap agreement including amending the terms of the swap agreement to reflect the new concept and timeline.
- Consider negotiations with Oklahoma and/or the USACE for access to additional water in Lake Texoma to supply a potential desalination strategy.
- Continue with planned treatment and conveyance projects, including:
  - Water Quality Improvements Programs,
  - Bachman WTP and Elm Fork WTP improvements needed to achieve reliable treatment capacities of 150 MGD and 310 MGD within the next 5 to 10 years,
  - Eastside WTP Expansion to 540 MGD with associated high service pumping and pipeline improvements by 2030,
  - Eastside raw water conveyance improvements including construction of the 144 inch diameter pipeline from Lake Tawakoni by 2030, and
  - Western Subsystem WTP expansion or new Southwest WTP by 2050.

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1 Introduction

1.1 Authorization

In August 2012, Dallas Water Utilities (DWU) staff briefed the Dallas City Council concerning the need to update Dallas' previous long-range water supply plan. In September 2012, the City of Dallas retained HDR Engineering, Inc. (HDR) to develop the 2014 Dallas Long Range Water Supply Plan (2014 LRWSP). The development of the 2014 LRWSP was authorized under Contract No. 12-015E as approved at the September 26, 2012 Dallas City Council meeting as agenda item No. 41.

1.2 Objectives and Scope

The last full review of Dallas' Long Range Water Supply plan was in 1989 with subsequent updates in 2000 and 2005. Since 1997, when Senate Bill 1 was passed, Dallas has participated in the state water planning process as overseen by the Texas Water Development Board (TWDB) through Dallas' participation in the Region C Regional Water Planning Group (Region C RWPG). The Region C planning cycle required Dallas provide a list of Recommended and Alternative Water Management Strategies (WMS) to the Region C RWPG in late 2014 for inclusion in the 2016 Region C Regional Water Plan (RWP). Dallas realized the need to develop a new water supply plan that will not only be consistent with the Region C Planning effort, but will provide a greater level of specificity for Dallas to identify, evaluate, plan for and implement future water management strategies. The objectives of the 2014 LRWSP are to:

- Update population and water demand projections through 2070 considering revisions to Dallas' service area,
- Review current and future supply quantities from existing supplies through 2070,
- Analyze the impact of water conservation on demand,
- Compare alternative water management strategies,
- Identify treatment, transmission and other infrastructure needs, and
- Recommend an implementation plan.

The scope of work for the development of the 2014 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,
- Evaluating, ranking and selecting water supply strategies,
- Identifying infrastructure requirements and integration plans, and
- Developing implementation plans for selected strategies and preparation of a report.

The result of this effort is the development of the 2014 LRWSP for Dallas to meet the demands of its citizens and customers through 2070 and beyond. The potential exists for future droughts to occur that may be worse than previous droughts due to the effects of a warmer climate. Therefore, the 2014 LRWSP considers a modified climate scenario that includes an average 7 degree F temperature increase occurring between 2000 and 2070. The consideration of the effect of this potential temperature increase on reservoir evaporation and the associated reduction in reservoir yields, allows Dallas to consider droughts that could occur in the future that may be more severe than previous droughts.

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 recent updates occurring in 2000 and 2005. Dallas' previous plans serve as the building blocks upon which the current LRWSP has been developed. Table 1-1 includes a listing of the more significant study efforts, including several recent studies performed by or participated in by Dallas, that have been considered during the development of this plan. Other relevant documents were utilized in the development of the LRWSP and are referenced throughout this report.

Table 1-1. Studies referenced during the development of the Dallas 2014 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
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

1.4 Study Methodology

Dallas' 2014 LRWSP follows the methodology used in the development of Dallas' previous plans and the regional and state water plans. 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 and trends as estimated by the TWDB for the 2016 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 2070 and includes the recommended strategies to meet these needs. Section 7 includes evaluations of the preferred 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.

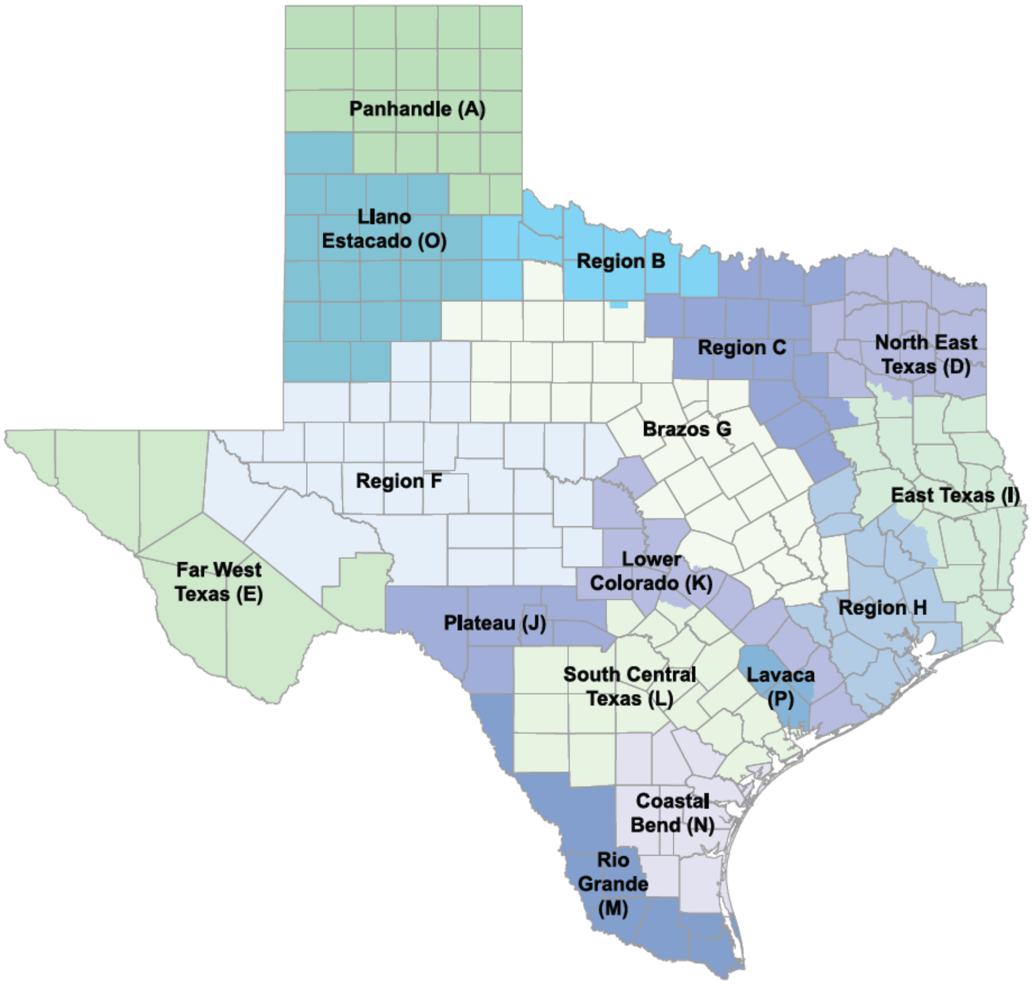
While the 2014 LRWSP relies on population and demand numbers provided by the TWDB for use in the 2016 Region C planning effort, the 2014 LRWSP takes these a step further by disaggregating demands by pressure plane within the Dallas system. Additionally, while estimates of current and future supply available from Dallas sources developed for the 2014 LRWSP are similar to those developed for the 2016 Region C RWP, more emphasis is placed on Dallas' operating policies and methods when applying various modeling assumptions.

These assumptions consider the 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 as developed by HDR for Dallas as part of the Integrated Pipeline project (IPL) being undertaken in cooperation with the Tarrant Regional Water District (TRWD). 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 101-year period beginning January 1907 and ending December 2007. 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 has the ability to perform yield analyses for all of the reservoirs, optimize system operations, and make statistical lake level projections. The Dallas RiverWare model was a significant tool used in the development of the LRWSP, and will continue to play a key role as strategies are implemented and incorporated into Dallas operations.

[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 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

A comprehensive list of potential strategies that could be available to meet Dallas' needs was identified as part of the planning effort. This effort identified over 300 strategies from previous plans and studies as well as new strategies identified as part of this planning effort. These strategies were evaluated using a methodology similar to that used in the Regional Planning effort but considered assumptions specific to Dallas, resulting in a more representative Dallas-focused evaluation. These strategies were 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.

1.4.1 Coordination with Related Studies

A number of related studies were underway during the development of the 2014 Dallas LRWSP and information from these studies was included in the LRWSP. These studies include:

- 2016 Region C RWP,
- Sulphur River Basin Wide Feasibility Study,
- Upper Neches River Water Supply Project Feasibility Study, and
- Dallas Reclaimed Water Delivery System Feasibility Study – Bureau of Reclamation.

1.4.2 Public Involvement

The study team conducted public meetings during the planning process to solicit input from citizens, customer cities, and select stakeholders including environmental interests. Public meetings were held in May of 2013 at two different locations at different times of the day to capture as diverse an audience as possible. The public meetings included a presentation by DWU staff and the study team to present preliminary study findings and overall goals of the planning process. Additional meetings were held with targeted stakeholder groups including the environmental community, where they were invited to offer input on strategies and selection criteria. These meetings were documented and comments were addressed as appropriate throughout the planning study. Additionally, public meetings were held in September and October 2014 to present the findings of the 2014 LRWSP to the Dallas City Council and to receive input from both the City Council and concerned citizens.

1.4.3 Coordination with Customer Cities

Early in the planning process, the study team held multiple meetings at different locations to receive input from Dallas' customer cities. Prior to these meetings, population, per capita use and water demand data was sent to each customer city in order to provide a summary of Dallas' planning expectations for that customer. The intent was to start a dialogue early on that provided the best information on which Dallas could build the plan. A summary of these meetings and the information exchanged is discussed in Section 4.

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2 Planning and Service Area

2.1 Introduction

The critical drought of the 1950's in Texas and its effect upon Dallas water supplies heightened the need for water supply planning and additional supply improvements. This experience, probably as much as any other event, propelled the City of Dallas on a future course of service extensions and supply expansion projects. Today the Dallas Regional Water Supply System serves a population of almost 3 million people in Dallas and the surrounding counties. Dallas Water Utilities (DWU) is the organization that manages the regional water system for the City of Dallas and serves to be an efficient provider of superior water and wastewater service and a leader in the water industry. A series of periodic long range water supply plans and updates and other supporting planning studies have been prepared by Dallas which document the growth of Dallas' evolving service area along with future water needs and supply strategies.

The 2014 LRWSP serves to continue this effort of proactive planning to meet the future water needs of Dallas and its customers.

A fundamental key step to the planning process is to identify the area anticipated to be served by DWU over the course of the planning horizon. This service area is comprised of the citizens of Dallas (retail customers), wholesale customers (treated and untreated), and other commercial / industrial customers that are served by DWU. The planning area definition is derived from existing policies of DWU as defined by various service agreements and previous studies. The following sections describe the basis for the existing service area.

2.2 History of Dallas' Service Area

The first Dallas long-range water supply study was conducted in the late 1950s (1959 Study). This study recommended that future service considerations should consider all of Dallas County and its 29 incorporated cities at that time, and stated: *"it is obviously impractical for each of these cities to develop an independent surface water supply to meet its long range needs."* Another concern in defining the broader county-wide water service area was *"recognizing the close relationship between the economic growth and welfare of the City of Dallas and these satellite cities comprising the metropolitan area."*

In 1980 a new study[1] was undertaken by Dallas that started with an 18-county study area of North Texas classifying tiered groups of counties by proximity to the City of Dallas or DWU reservoirs. This study considered a variety of criteria including population, adequacy of existing water supply, proximity to other supplies, and other factors while also identifying different options for extending water service. In December 1984, the Dallas City Council adopted a formalized treated water service policy that was then published in January 1985 (1985 Policy)[2]. The 1985 Policy identified a service area

[1] Service Area Delineation Study, City of Dallas; Peat, Marwick, Mitchell & Co.; 1980.
[2] Conditions of Service for New Treated Water Wholesale Customers. Approved by Dallas City Council on December 19, 1984. Council Chamber Reference: 844011.

boundary and also formalized various conditions of service that must be met for water service extensions.

In 1989, DWU again updated its long-range water supply plan. The service area boundaries utilized in the 1989 LRWSP evolved to recognize the finding of recently completed regional studies for Ellis, Collin, Denton and Tarrant counties and other changed conditions. The 1989 study update modified DWU service area boundaries in Cooke and Grayson counties to the north and slightly extended DWU's service area into Tarrant, Ellis and Kaufman counties to the south, recognizing the local service area of DWU wholesale customers whose city limits extend into those adjoining counties.

DWU performed another update to its long range water supply plan in 2000. This time, the service area boundary was changed to include a small area in northeastern Tarrant County adjoining the southern side of Lake Grapevine for possible service to the City of Grapevine and inclusion of a more considerable area in Ellis County to the south, reflective of a water supply request from Rocket SUD and related entities.

2.3 Planning Area from 2005 LRWSP

Because of rapid growth in the Dallas and Fort Worth (DFW) Metroplex[3] in the early 2000s, changing water rights and environmental regulations, heightened competition for water, and increased difficulty of developing new water supplies, Dallas initiated a more frequent 5-year cycle for its LRWSP with a planning study performed by Chiang, Patel & Yerby (2005 LRWSP update). Service area evaluation criteria, similar to the 2000 LRWSP update, were utilized in the 2005 LRWSP update. Wholesale water service to the City of Wilmer, already within the existing DWU service area boundary, was incorporated in the 2005 LRWSP update, along with the inclusion of a small area in northwestern Ellis County, which included a portion of Johnson County SUD's service area to the west. Figure 2-1 shows the service area as represented in the 2005 Update.

[3] Metroplex is defined as a contiguous metropolitan area that has more than one principal anchor city of near equal importance. Metroplex is used throughout the report in reference to the Dallas / Fort Worth Metroplex (DFW).

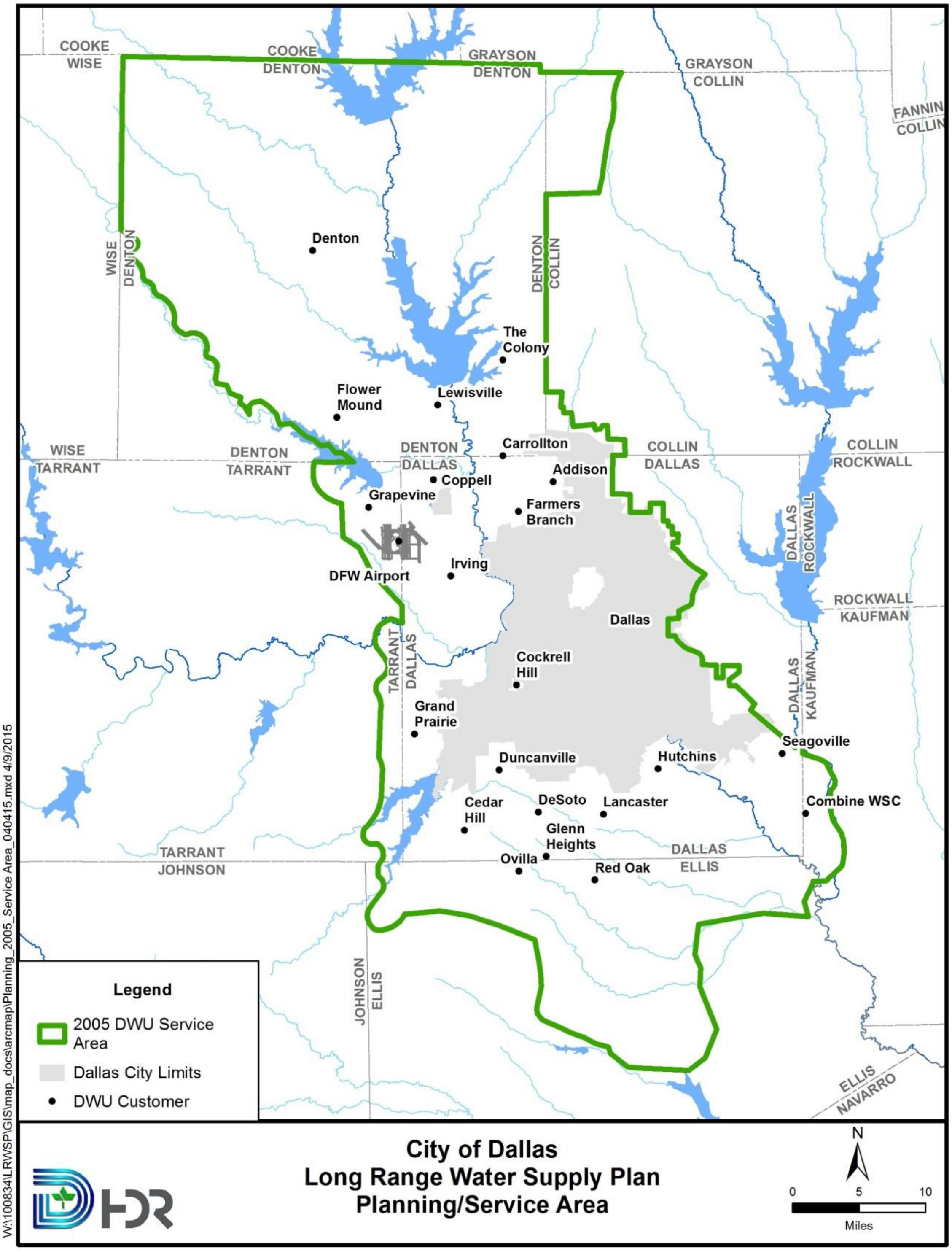
2.4 Existing Service Area

For the 2014 LRWSP Dallas has decided to rely on a different method to define its service area that provides a more accurate representation than previous efforts. Table 2-1 provides a summary of the current customers that are considered part of the Dallas Regional Water Supply System. This table contains the name of the entity, type of supply (untreated, treated, or treatment only), current contract amount, contract expiration date (all contracts are assumed to renew and the Dallas 2014 LRWSP takes this into account), approximate current use, and estimated use in 2070 was used in the 2014 LRWSP.

Dallas considers its service area to be the area serviced by its existing customers. This concept is represented by the maps contained in Figure 2-2 through Figure 2-4. Figure 2-2 represents Dallas' treated water customers, listed in Table 2-1, and the area served by those entities. Figure 2-3 represents Dallas' untreated water customers, listed in Table 2-1 and the area served by those entities. Figure 2-4 shows the combined treated and untreated service area for Dallas. 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 Dallas' service area obligations.

Dallas does not currently anticipate acquiring new customers over the planning horizon. However, if requests for service are received by Dallas they will be evaluated on a case by case basis for service to see if these requests are consistent with current Dallas service policies and if the additional demands can be met by Dallas at that time.

Figure 2-1. Service Area as Defined in the 2005 LRWSP Update



Source: Chiang, Patel & Yerby, 2005 Dallas Long Range Water Supply Plan Update

Table 2-1. Summary of Dallas Customers - Current and Projected 2070 Demands[4]

Entity Name	Type of Supply	Contract Expiration Date	Approximate Current Demand on Dallas (MGD)	Projected Demand on Dallas in 2070 (MGD)
Addison	Treated	Jan. 6, 2042	5.4	10.4
Balch Springs [a]	Treated	Sep. 11, 2015	2.5	3.4
Carrollton	Treated	Jun. 29, 2043	21.0	20.4
Cedar Hill[b]	Treated	Sep. 26, 2044	9.3	15.2
Cockrell Hill	Treated	Feb. 22, 2044	0.4	1.0
Combine WSC[c]	Treated	Dec. 14, 2035	0.3	0.6
Coppell	Treated	Nov. 18, 2017	9.8	9.9
Dallas Retail	Treated	N/A	245.6	359.3
Dallas County-Other	Treated	N/A	0.8	0.3
Denton	Untreated	Aug. 7, 2015	0.0	56.7
DeSoto	Treated	Aug. 24, 2043	8.4	12.2
DFW Airport	Treated	Oct. 23, 2015	2.6	4.1
Duncanville	Treated	Sep. 30, 2044	5.4	5.5
Ellis County WCID #1	Treated	Aug. 13, 2033	0.0	0.0
Farmers Branch	Treated	Aug. 1, 2040	8.1	10.4
Flower Mound	Treated	Jan. 21, 2017	7.6	7.8
Glenn Heights	Treated	Feb. 12, 2022	1.6	5.7
Grand Prairie	Treated	Jan. 6, 2042	19.6	30.0
Grapevine [d]	Untreated	Jun. 14, 2030	3.1	3.0
Hutchins [e]	Treated	Mar. 31, 2042	1.3	6.0
Irving	Treated	Jun. 30, 2033	15.3	4.5
Irving [f]	Treatment	Jun. 30, 2033	53.4	56.8
Lancaster	Treated	Nov. 11, 2041	6.8	13.5
Lewisville	Treated	Jun. 4, 2016	1.1	12.8
Lewisville [h]	Untreated	Dec. 17, 2016	18.0	18.0
Ovilla	Treated	Dec. 14, 2035	1.0	4.1
Red Oak	Treated	Aug. 13, 2033	0.1	1.7
Seagoville	Treated	Feb. 2, 2043	1.8	3.2
The Colony	Treated	Nov. 4, 2040	5.9	6.3
UTRWD[i]	Untreated	Feb. 12, 2022	34.2	54.0
Manufacturing Uses [j]	Treated	N/A	24.4	30.5
Mining Uses [j]	Treated	N/A	0.3	0.2
Steam-Electric Uses [j]	Untreated	Jan. 1, 2051 [k]	4.5	4.5
Irrigation Uses [j]	Untreated	Varies	2.6	2.6
Total			**468.8**	**717.8**

[a] Balch Springs was previously listed under the now dissolved Dallas County WCID #6. Dallas County WCID #6 was dissolved in 2014.

[b] Negotiated, but not yet approved as of Nov. 2, 1014.

[c] Combine WSC supplies the City of Combine.

[d] No contract maximum. Amount supplied is dependent on water availability. The contract estimates that 1.8 MGD will be used in any given year.

[e] Hutchins serves the community of Wilmer. Wilmer does not have a contract with Dallas, but Wilmer's demands are included as a part of Hutchins' demand.

[f] These values include the treated water demand for Irving and are not additive. Dallas has reserved 63 MGD on a peak day basis for treatment of Irving water (37.1 MGD on an average day). In addition, Dallas may commit up to 14 MGD of additional treatment capacity if deemed available.

[h] There is no contract maximum for the untreated water. Amount supplied is dependent on water availability. The contract estimates that approximately 20.6 MGD (23,094 acft) would be needed in 2010, the last year for which a projection was available.

[i] Although there is no set maximum to the contract, the amount supplied under the contract is dependent on certain service arrangements. It was originally projected that UTRWD would need about 39.1 MGD (43,825 acft) of water from Dallas in 2020. Dallas serves 10 MGD plus the following cities through UTRWD: Argyle WSC, Carrollton, Coppell, Denton (including Corinth and Lake Cities MUA), Flower Mound, Highland Village, and Lewisville.

[j] County aggregated demands from the 2016 Region C RWP.

[k] Luminant contract.

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[4] Dallas currently holds a contract with the North Texas Municipal Water District (NTMWD) for 60 MGD that is not shown on Table 2-1. The contract is for untreated water and will expire on 4/23/2016 (a 3-year contact). This contract is considered a temporary demand on the Dallas system, due to the extreme drought (as of the publication of this report) being experienced by NTMWD, and not a demand that Dallas plans to meet long-term.

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

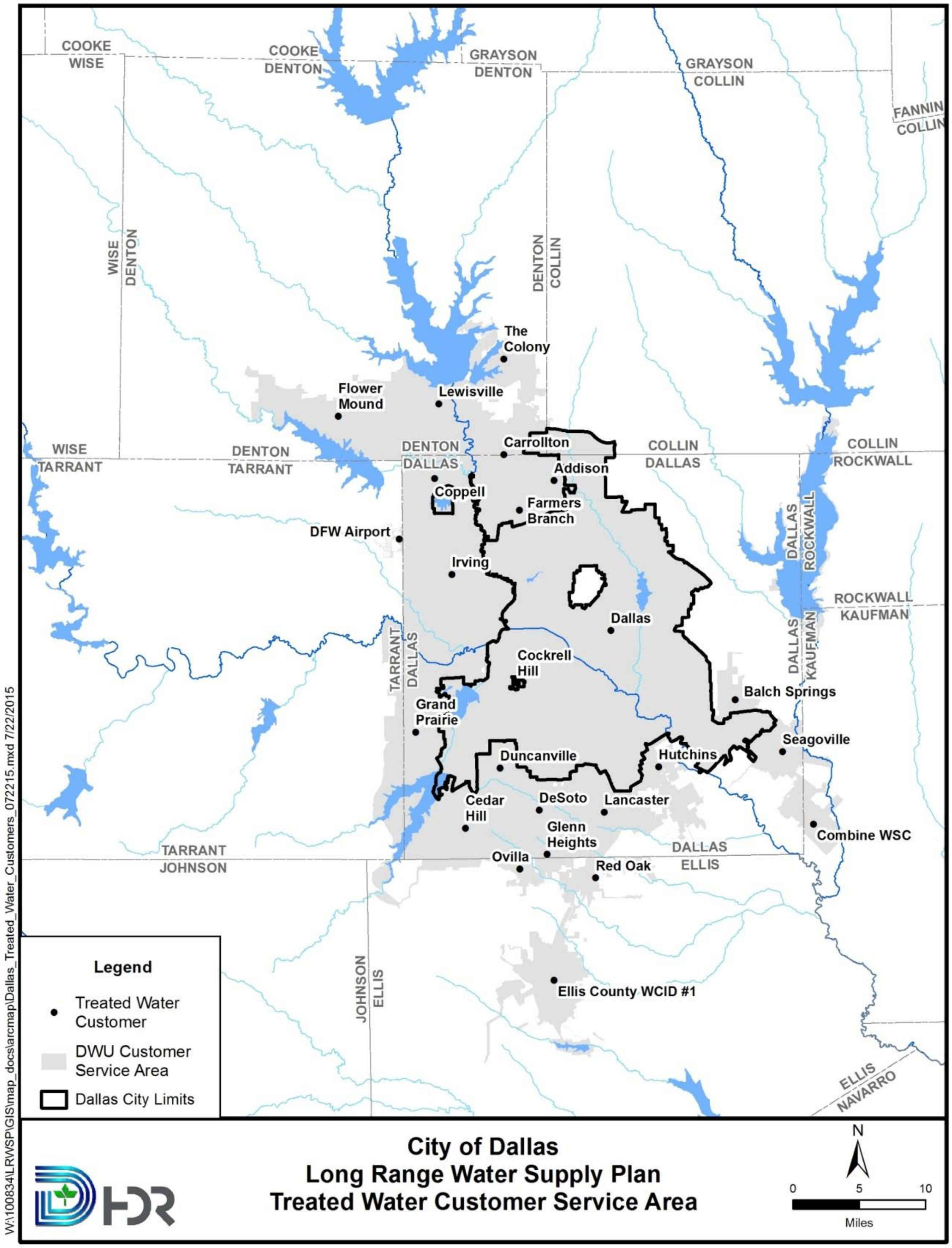


Figure 2-3. Area Served by Dallas' Untreated Water Customers

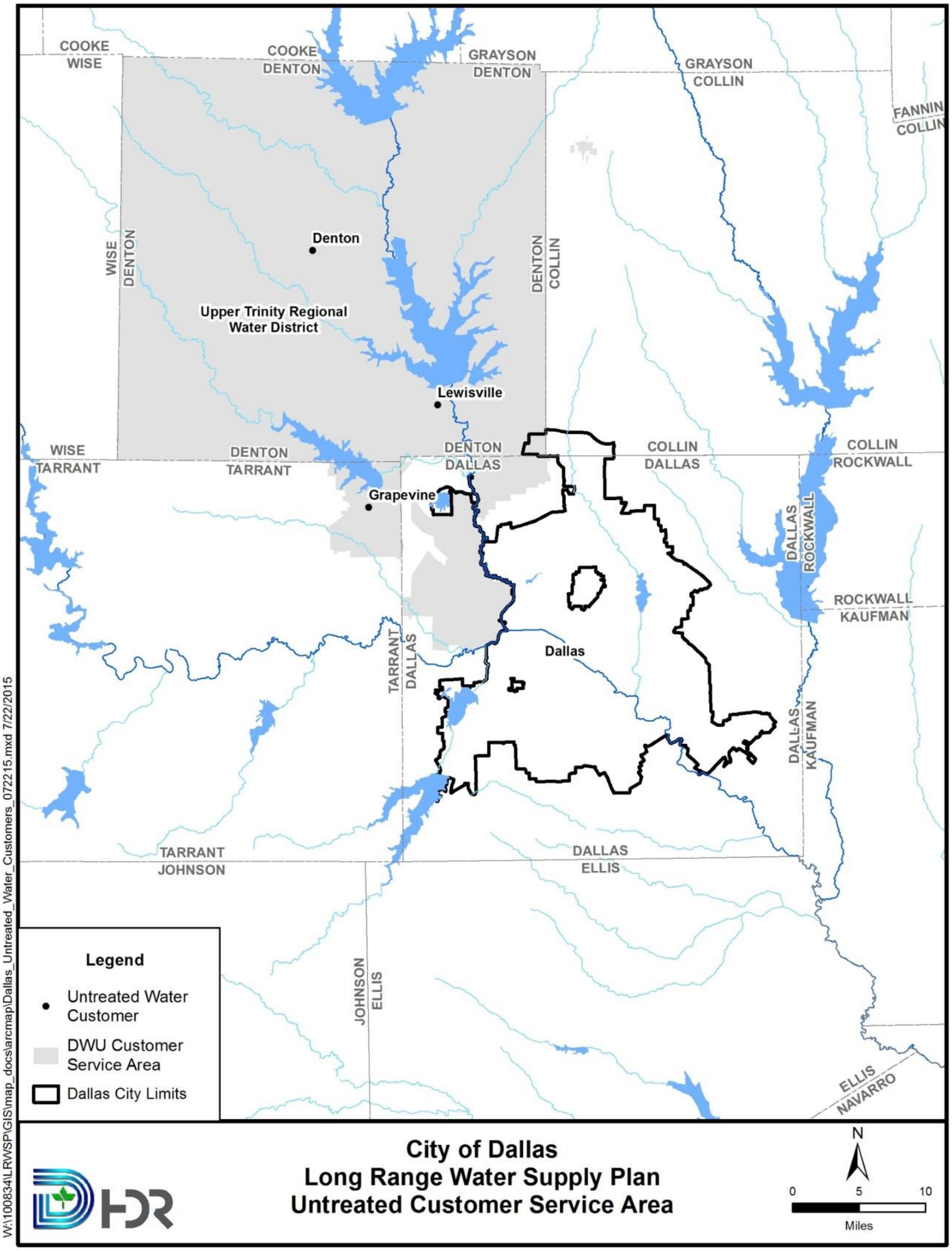
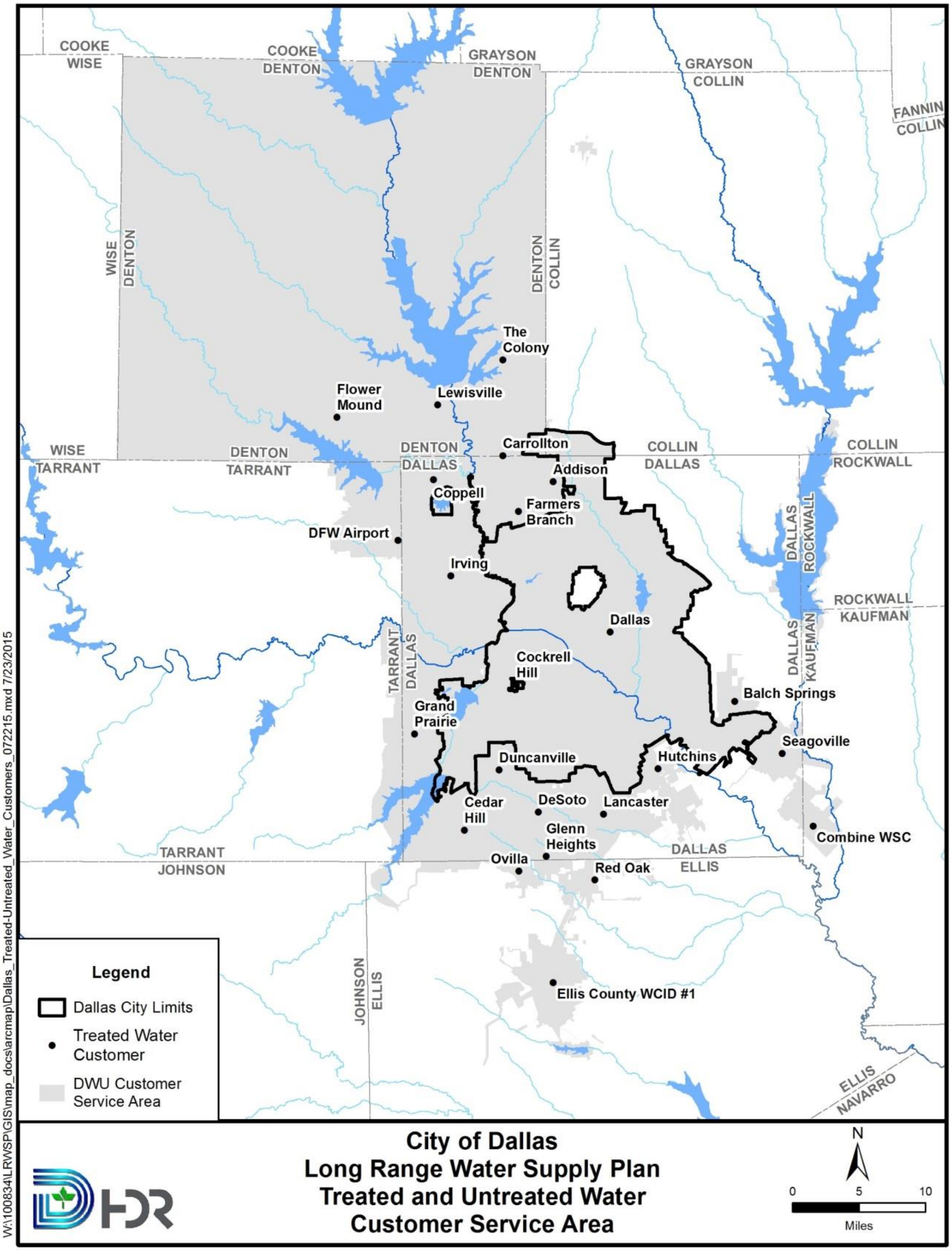


Figure 2-4. Combined Service Area for Dallas' Treated and Untreated Water Customers



W:\100834\LRWSP\GIS\map_docs\arcmap\Dallas_Treated-Untreated_Water_Customers_072215.mxd 7/23/2015

2.5 Adjacent Areas Served by Other Agencies

Part of understanding Dallas' service area is to understand what areas are served by other Metroplex area water providers. There are four large wholesale providers that surround the Dallas service area that limit Dallas's ability to expand into these areas. Figure 2-5 is a regional map that shows how the service areas and current customers of these wholesale water providers border the area of Dallas's customer cities.

2.5.1 North Texas Municipal Water District (NTMWD)

NTMWD supplies treated water to customers in suburban communities located north and east of Dallas. The District obtains raw water from Lake Lavon, Lake Texoma, and Chapman Lake, all of which are owned and operated by the Corps of Engineers. 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. Additionally the NTMWD has a temporary contract to purchase water from DWU which expires in April of 2016.

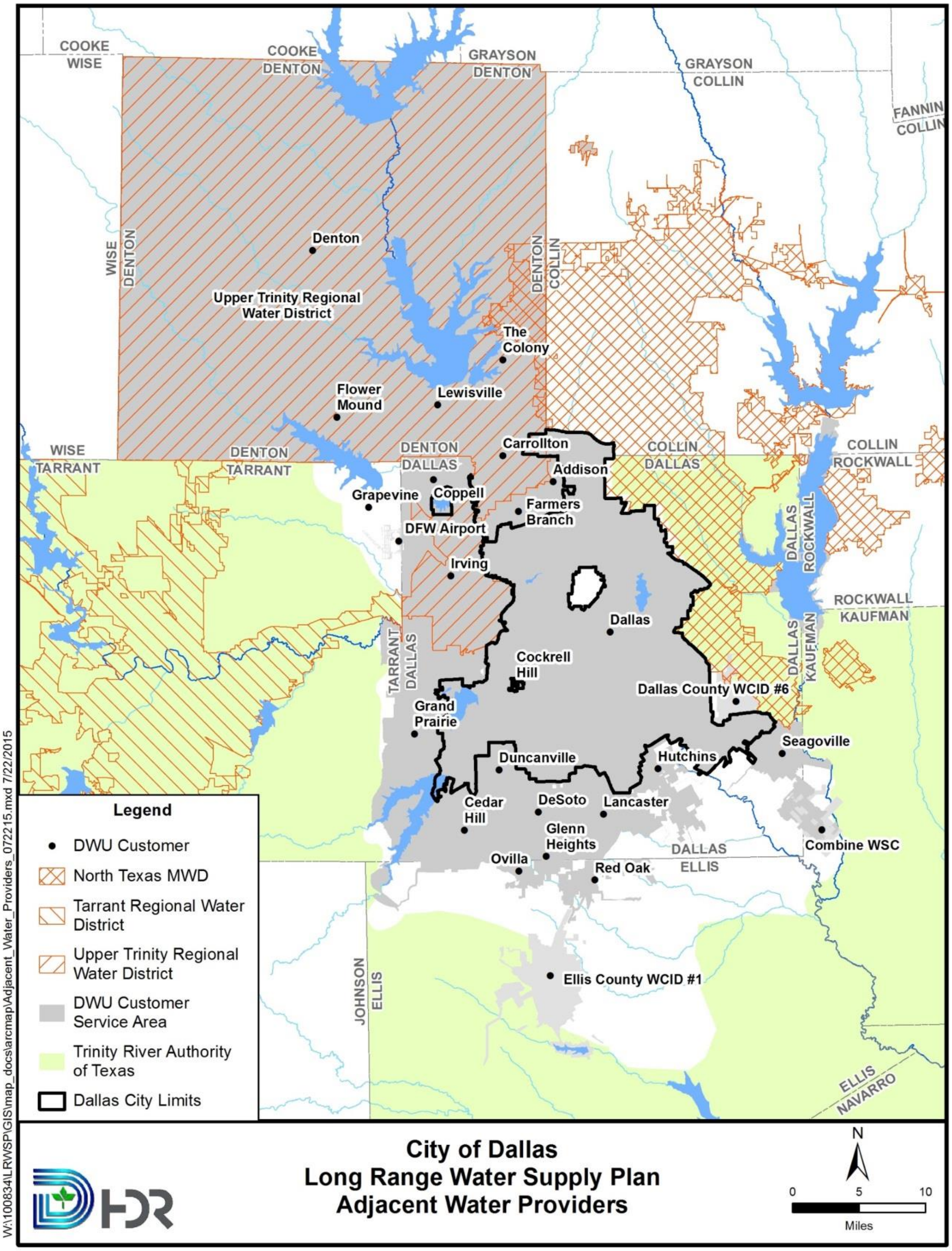
2.5.2 Tarrant Regional Water District (TRWD)

TRWD supplies raw water to customers in Tarrant County and nine other surrounding counties, including Johnson County. 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.

2.5.3 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.

Figure 2-5. Service area of Dallas and Its Customers and Adjacent Water Service Area Boundaries



2.5.4 Upper Trinity Regional Water District (UTRWD)

UTRWD operates a regional water supply system in Denton County, which is a rapidly growing area. UTRWD has a contract with the City of Commerce to divert up to 14.4 MGD (16,106 acft/yr) of 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 Dallas and Denton and has an indirect reuse permit to reuse a portion of the water discharged to Lake Lewisville.

2.6 Recommended Planning Area

HDR, in cooperation with Dallas, is recommending that Dallas' planning area for the 2014 LRWSP be the same as the current service area and list of current customers. Dallas is not actively planning to meet the needs of any entity other than those that it currently serves within its service area. The 2014 LRWSP is focused on meeting the needs of a growing City of Dallas and the growth of its current customer cities.

During the planning process for the 2014 LRWSP, four entities did approach Dallas about receiving treated water service. These entities are:

- Heath,
- Rocket Special Utility District (SUD),
- McClendon-Chisolm, and
- Sunnyvale.

Currently these entities are not within Dallas' service area, and the decision to serve these entities has not been completed. The demands of these entities as shown in the 2016 Region C RWP data are within a range that Dallas could serve without significant impact to the planned implementation of strategies presented in this report. However, as of the time of publication of this report, no decision has been made to serve or plan for these entities.

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3 Population Projections

3.1 Introduction

This section provides background information for population projections used in the preparation of the 2014 LRWSP. Population projections are consistent with those being used in the 2016 Region C RWP as of September 12, 2014. This section also includes comparisons of the 2014 LRWSP population projections to those used in the 2005 LRWSP and the 2011 Region C RWP for reference.

3.2 Basis of Population Projections

As part of the 2016 Region C RWP process, the Texas Water Development Board (TWDB) developed new population projections for each of the entities in Region C, including the City of Dallas and each of its customers. The draft population projections were released by the TWDB in April 2013 and considered the results of the 2010 U.S. Census data. After receiving these projections from the TWDB, Dallas forwarded a summary to each of its customers for comment. (These entities had an opportunity to provide comment to the TWDB through the Region C planning group.) The City of Dallas then held two workshops allowing customer cities the opportunity to provide feedback on the projections. Several of the customer cities attended one of the workshops or otherwise responded with comments. After working with the customer cities, changes were made to the original TWDB draft projections to better reflect the anticipated populations of the City of Dallas and its customer cities. These revised projections were submitted to the TWDB for review and were subsequently approved (with minor modifications) by the TWDB for use in the 2016 RWP.

The TWDB initially released draft population projections for the City of Dallas and Dallas County with the knowledge that the City, working with the Region C consultants, would provide significant direction to the TWDB concerning future population projections for the City as well as unincorporated areas within the county. These draft population projections along with three alternative projections (based on low, medium and high growth rates) were presented and discussed at two public meetings held in Dallas in May 2013. After receiving input on these alternative projections, Dallas chose to use the "medium" population growth forecast. This medium growth forecast resulted in Dallas' population increasing between 2020 and 2070 from approximately 1.24 million to approximately 1.90 million people as shown in Figure 3-1 and Table 3-1. Additional details of the TWDB population and gpcd methodology are included in Appendix A.

3.3 Updated Population Projections

Population projections for the City of Dallas and its customer cities are summarized in Figure 3-1 and Table 3-1. Table 3-2 provides a summary of the City of Dallas population projections, projections for customer cities, and the total population projections. In 2020, the total population of Dallas and its customer cities is projected to be 3,062,874, while the City of Dallas population is projected to be 1,242,135 (or 40.5 percent of the total area population). In 2070, the total population of Dallas and its customer cities is projected to be 5,335,956, while the City of Dallas population is projected to be 1,905,498 (or 35.7 percent of the total area population).

Table 3-2 disaggregates Dallas' population for each major pressure zone with the methodology used to develop these estimates described in Appendix B. A map showing Dallas' major pressure zones is shown in Figure 3-2. Finally, Table 3-3 displays the population projections for each individual customer and user group.

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

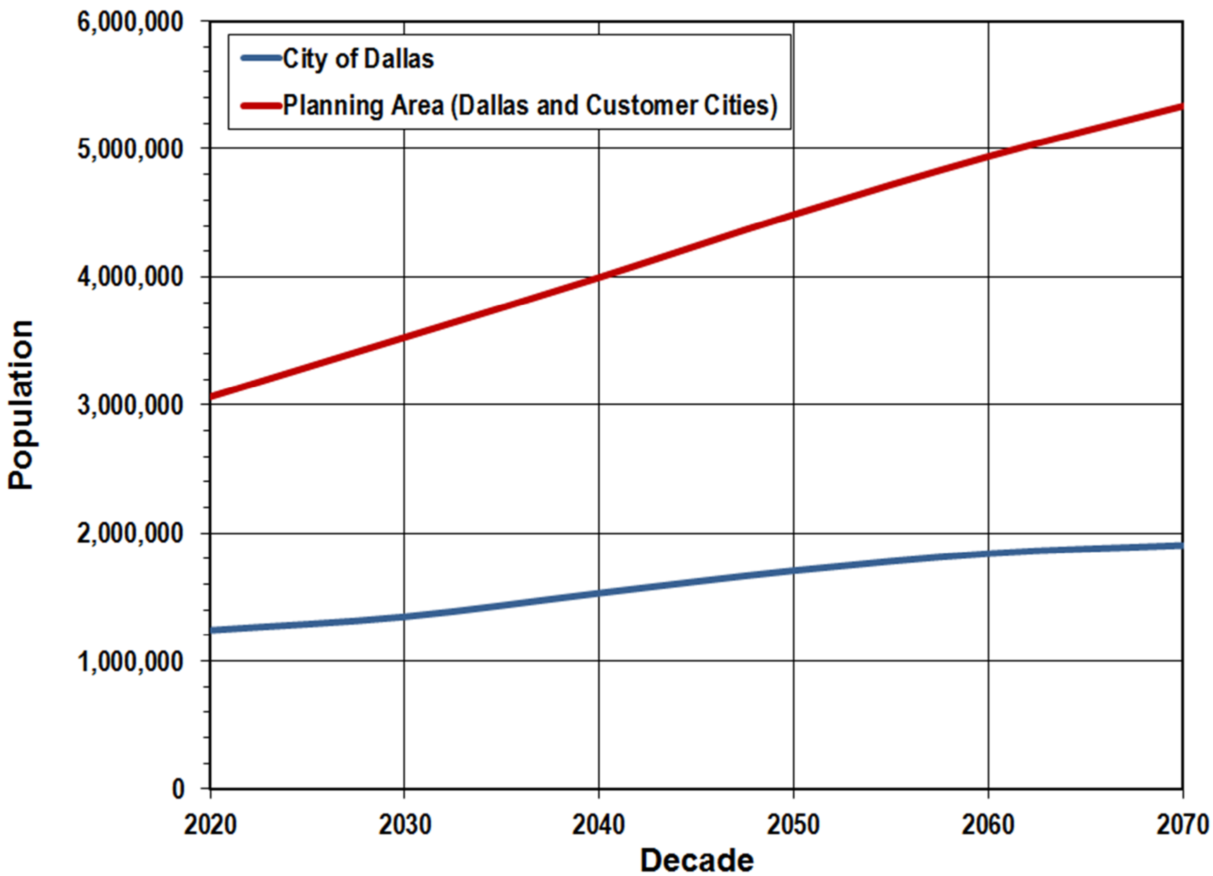

Table 3-1. Population Projections for City of Dallas and its Customer Cities

table units: number of people

Entity	2020	2030	2040	2050	2060	2070
City of Dallas	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498
Customer Cities	1,820,739	2,179,474	2,464,242	2,781,101	3,100,019	3,430,458
Total Population	**3,062,874**	**3,527,191**	**3,995,923**	**4,488,158**	**4,941,083**	**5,335,956**

Source: 2016 Region C data as of September 12, 2014.

Table 3-2. Population Projections for City of Dallas (by Major Pressure Plane)

table units: number of people

Dallas – Major Pressure Plane	2020	2030	2040	2050	2060	2070
Arcadia Park	7,318	10,856	13,601	17,116	20,574	23,487
Cedar Dale High	7,383	12,675	17,049	22,556	28,167	33,134
Central Low	328,926	371,656	439,944	509,414	570,032	611,368
East High	115,473	118,753	127,449	134,081	136,007	131,852
Meandering Way High	72,707	75,495	81,731	86,671	88,703	86,861
Mountain Creek High	6,176	7,744	11,356	14,882	18,456	21,595
North High	355,182	369,553	406,167	436,070	452,367	449,606
Pleasant Grove Intermediate	117,798	125,529	142,827	158,980	171,243	177,011
Red Bird High	29,879	36,863	47,171	57,723	67,818	75,959
South High	156,974	172,815	195,066	217,470	234,617	242,905
Trinity Heights Intermediate	44,319	45,778	49,320	52,094	53,080	51,720
City of Dallas Total	**1,242,135**	**1,347,717**	**1,531,681**	**1,707,057**	**1,841,064**	**1,905,498**

Source: 2016 Region C data as of September 12, 2014.

3.4 Previous Population Projections

Population projections for the DWU service area from the 2011 Region C RWP and the 2014 LRWSP are shown in Figure 3-3 and Table 3-4. While population projections were developed as part of the 2005 Dallas LRWSP, those projections did not include population estimates for some entities (i.e. Upper Trinity Regional Water District) and therefore are not directly comparable to the projections from the 2011 RWP and are not included in the figure. It can be seen from Figure 3-3 that the population projections for the 2014 LRWSP are slightly lower than the 2011 RWP projections. In 2020, the recent projections are 163,816 people fewer (or a 5.1 percent decrease). In 2040, the recent population projections are only 37,260 people fewer (or a 0.9 percent decrease). And finally, in 2060, the recent population projections are 164,705 people fewer (or a 3.2 percent decrease).

Although it is difficult to compare the updated total service area population projections with those used in the 2005 LRWSP, we can compare the projections for the City of Dallas. In 2020, the 2005 LRWSP had a projected population for the City of Dallas of 1,451,878 which is 16.9 percent higher than the recent estimate. In 2040, the 2005 LRWSP had a projected population for the City of Dallas of 1,598,222 which is 4.3 percent higher than the latest estimate. Finally, in 2060, the 2005 LRWSP had a projected population for the City of Dallas of 1,700,000 which is 7.7 percent lower than the recent estimate. Appendix C includes an analysis of the population projection comparison by individual entity.

Figure 3-2. Major Pressure Planes for City of Dallas

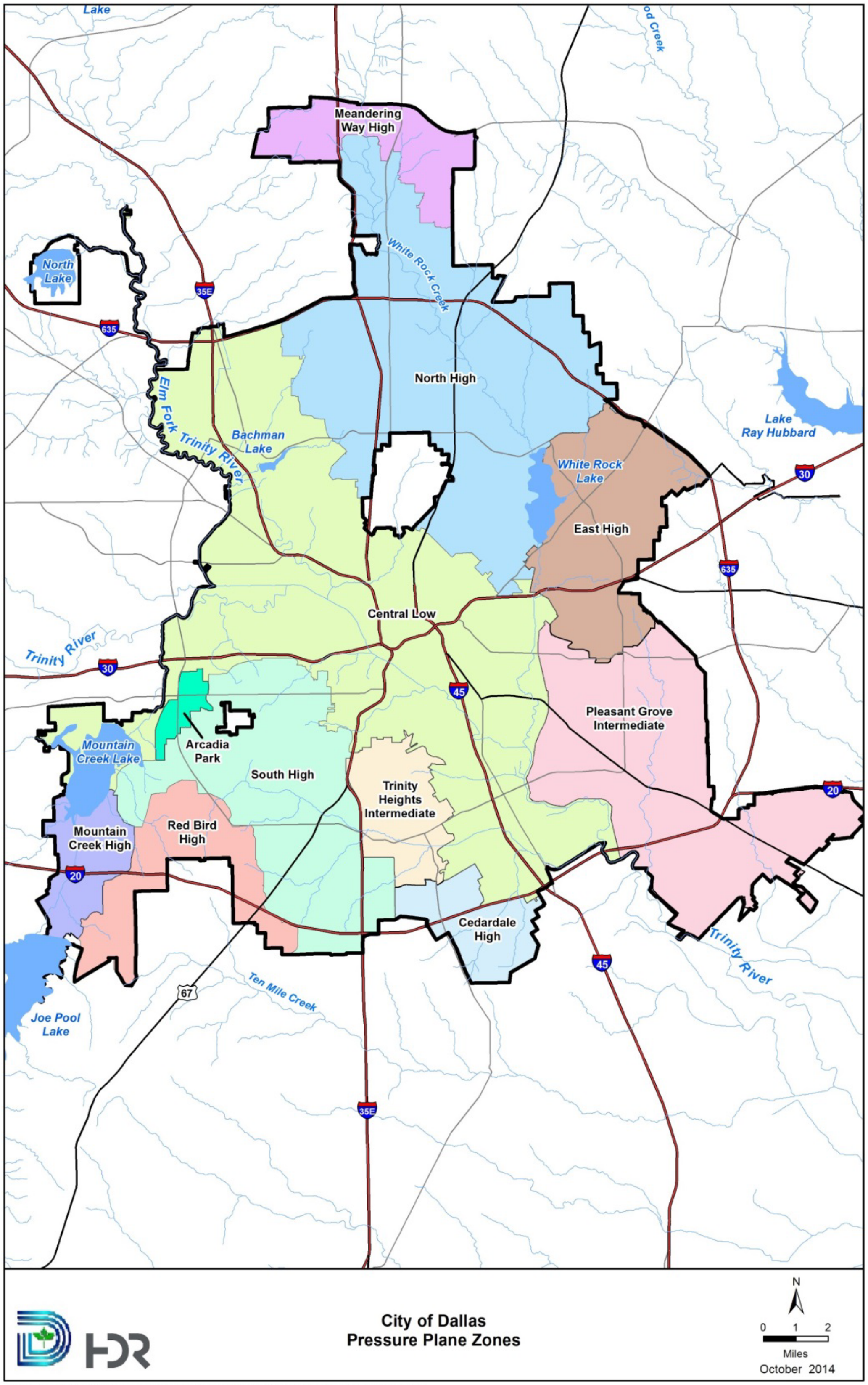

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Table 3-3. Population Projections for Dallas Customers

table units: number of people

Entity	2020	2030	2040	2050	2060	2070
Addison	14,539	17,431	20,323	23,215	26,107	29,000
Carrollton	126,763	129,176	129,179	129,182	129,185	129,188
Cedar Hill	53,200	65,119	77,038	88,956	88,956	88,956
Cockrell Hill	4,670	5,122	5,122	5,122	7,000	15,000
Combine WSC [a]	15,829	17,093	24,432	38,000	65,000	90,000
Combine	2,690	3,278	3,939	4,692	5,545	6,501
Coppell	41,460	42,953	42,953	42,953	42,953	42,953
Balch Springs [c]	26,423	28,980	31,606	34,456	37,233	40,018
Dallas County-Other	5,339	3,000	2,000	2,000	2,000	2,000
Denton	158,398	205,977	262,057	341,471	468,168	570,694
DeSoto	54,617	59,903	65,330	71,222	76,963	82,718
DFW Airport	N/A	N/A	N/A	N/A	N/A	N/A
Duncanville	42,927	47,106	47,106	47,106	47,106	47,106
Farmers Branch	30,613	32,509	34,455	36,567	38,625	40,689
Flower Mound	75,555	93,000	93,000	93,000	93,000	93,000
Glenn Heights	17,323	23,308	29,590	36,506	43,522	59,000
Oak Leaf	1,350	1,500	1,750	2,500	3,700	4,500
Grand Prairie	218,162	258,759	283,493	283,515	283,541	283,571
Grapevine	52,414	58,930	60,000	60,000	60,000	60,000
Hutchins [b]	9,903	13,922	17,941	21,960	25,979	30,000
Wilmer	4,203	4,698	7,500	14,000	22,000	40,000
Irving	260,752	284,500	284,500	284,500	284,500	284,500
Lancaster	45,184	58,895	69,717	77,649	85,582	93,514
Lewisville	107,327	121,924	139,368	158,857	177,356	177,356
Ovilla	4,525	5,791	7,249	8,946	10,917	20,000
Red Oak	12,369	14,000	19,000	26,000	32,000	50,000
Seagoville	18,854	22,873	26,892	30,911	35,000	35,000
The Colony	51,000	58,000	62,000	67,600	67,600	67,600
UTRWD	364,350	501,727	616,702	750,215	840,481	947,594
Total Customer Population	**1,820,739**	**2,179,474**	**2,464,242**	**2,781,101**	**3,100,019**	**3,430,458**

Source: 2016 Region C data as of September 12, 2014.

Note: Customer population represents the total population of that entity, not necessarily the population of that entity served by Dallas.

[a] Combine WSC serves Combine.

[b] Hutchins serves Wilmer.

[c] Formerly Dallas County WCID #6, dissolved in 2014.

Figure 3-3. Comparison of Population Projections – 2011 Region C Water Plan and 2014 LRWSP

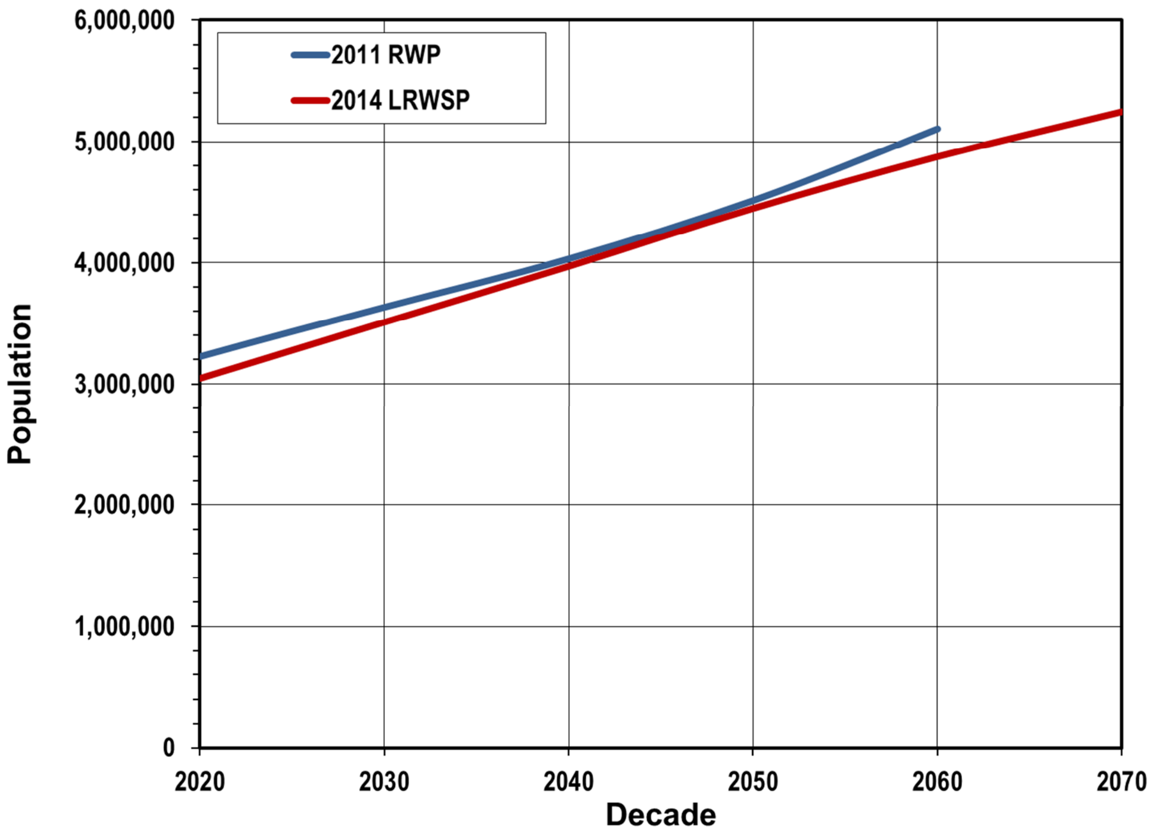


Table 3-4. Comparison of Population Projections – 2011 Region C Water Plan and 2014 LRWSP

Population Estimate	2010	2020	2030	2040	2050	2060	2070
2011 Region C Plan	2,790,133	3,226,690	3,634,425	4,033,183	4,515,013	5,105,788	-
2014 LRWSP	-	3,062,874	3,527,191	3,995,923	4,488,158	4,941,083	5,335,956
Percent Difference	-	(5.1%)	(3.0%)	(0.9%)	(0.6%)	(3.2%)	-

4 Water Demands and Wastewater Effluent Projections

4.1 Introduction

This section outlines the basis for the updated water demand projections for the 2014 LRWSP, and includes a comparison of the new projections with those in the 2005 LRWSP and the 2011 Region C RWP. The projected wastewater effluent volumes and the associated calculation methodology are also included in this section. The collective demands of Dallas and its customers are referred to as the DWU or DWU System demands throughout this report.

4.2 Basis of Water Demand Projections

There are three components that form the water demand projections. The first component is the service area, discussed in Section 2. The second component is the population contained in the service area, discussed in Section 3. Finally, per capita use of the population within the service area is the last component that is considered in developing future water demand. Water demand is estimated from these three components by multiplying the population served by the appropriate per capita use value, resulting in volume of water needed to serve the population at some point in the future.

Similar to the population projections, the water demand projections used for the 2014 LRWSP are based on the water demand projections developed as part of the 2016 Region C RWP process. For the Region C process, the TWDB developed water demand projections for each of the entities in Region C, including the City of Dallas and its customers. These water demand projections are based on a dry year per capita water use (normally 2011) and include conservation savings associated with the Texas Plumbing Fixtures Act, which requires all new and retrofitted plumbing fixtures to meet certain flow standards. The City of Dallas forwarded these summaries to each of its customers for comment. In addition, the City of Dallas held two workshops to allow customer cities the opportunity to provide feedback on the projections, and several of the customer cities attended one of the workshops or responded with comments. After working with the customer cities, changes were made to the original draft water demand projections released by the TWDB to include corrected data for the City of Dallas and its customer cities. These revised projections were subsequently reviewed and approved (with some modification) by the TWDB for use in the 2016 Region C RWP. For the City of Dallas, the TWDB approved a base gallons per capita per day (gpcd) use of 207.

All demand projections presented in the 2014 LRWSP for the City of Dallas use the approved base value of 207 gpcd. This base gpcd value of 207 represents the water use associated with the dry year that occurred in 2011. This base year value is adjusted based on the expected reduction in use from the implementation of the Plumbing Fixtures Act so that gpcd is reduced through time to realize these savings. Historical and future gpcd values for Dallas and its customers are presented in the following sections.

4.3 Per Capita Water Use Factors

To calculate total water demand for Dallas and each of its customer cities, a per capita water use factor was applied to the population values presented in Section 3. Table 4-1 shows historical gpcd values from 1999 to 2011 determined and obtained from the TWDB for Dallas and each of its customer cities. This table shows that in general, the City of Dallas gpcd values have been declining over time as Dallas' water conservation program has been implemented and expanded. Many of Dallas' customer cities show the same pattern with a few exceptions likely due to the mix of residential and commercial use within these cities as they continue to urbanize. The value for the year 2011 was selected by the TWDB as the base year used for future water demand forecasts, as this was deemed to be a hot and dry year and representative of drought conditions. Table 4-2 shows the gpcd values used to calculate projected water demands for the 2014 LRWSP beginning in the year 2020. The projected gpcd's decline over time is due to the fact that the TWDB assumes that some water conservation will occur naturally from the Texas Plumbing Fixtures Act, which requires all new or retrofitted plumbing fixtures to meet lower use standards. The City of Dallas gpcd is projected to be 198 in 2020, decreasing to 189 in 2070. The gpcd for the entire DWU service area is projected to be 185 in 2020, decreasing to 171 in 2070.

4.4 Water Demand Projections

Using the population projections from Section 3 and the per capita water use rates discussed above, a total water demand for each entity was calculated. For entities with multiple sources of water, a portion of its total demand was allocated to the DWU system and a portion of its demand was allocated to its other sources of supply. This process is discussed further in Section 4.4.5. A condensed summary of the water demand projections showing the total water demands of each entity and the total non-Dallas sources are shown in Appendix D.

The estimated water demands for DWU are summarized and parsed in Table 4-3 through Table 4-6. Table 4-3 shows the DWU water demand from three separate groups, the City of Dallas retail customers, Dallas' Customer Cities, and non-municipal customer demand. Table 4-4 shows Dallas' retail water demand disaggregated for each major pressure zone within the City using the methodology described in Appendix B. A map of Dallas' major pressure zones is shown in Figure 4-1. It is important to note that the demands shown for Dallas in Table 4-3 are only for the residential and commercial portion of the City's demand and do not include manufacturing demand, as those demands are shown in Table 4-5. Table 4-5 shows the projected water demand by the various non-municipal customers that are served by DWU. Table 4-7 displays the water demand projections for each individual municipal customer. Note that some municipal customers show a demand that stabilizes, or even decreases, through the planning horizon. This is a result of the entity reaching a build out condition with a steady, non-increasing population and a steady or even decreasing gpcd due to conservation efforts. Table 4-6 provides a summary of these demands on DWU by presenting the Dallas retail demand compared to the sum of its customer demand and the percentage that the customer demand is of the total demand. In Table 4-6 the values for the City of Dallas come from Table 4-3 and the data for the customers come from Table 4-5 and Table 4-7 summed together. The percentage is calculated by dividing the customer demand by the total demand.

Table 4-1. Historical gpcd Values for City of Dallas and Customer Cities

Entity	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Dallas	303	264	250	245	238	240	244	225	236	213	173	199	207
Addison	399	441	409	368	434	375	744	356	293	283	258	329	378
Carrollton	196	189	176	158	181	171	175	183	132	154	131	154	167
Cedar Hill			121	102	125	128	128	184	164	191	197	179	187
Cockrell Hill	118	117	121	91	117	95	96	92	85	85	84	90	88
Combine WSC	96	89	83	85	90	86	99	114	91	99	89	99	113
Combine	96	89	83	85	90	86	99	114	91	99	89	99	113
Coppell	193	179	193	199	197	227	214	257	177	221	217	221	245
Balch Springs [a]	105	110	106	100	104	113	113	122	100	109	104	96	102
Denton	164	189	170	139	144	152	152	160	134	137	124	143	157
DeSoto	190	190	174	157	172	159	159	193	191	160	160	147	163
Duncanville	173	172	167	158	155	166	160	166	127	142	127	125	136
Farmers Branch	333	333	292	282	316	274	326	294	226	262	200	268	263
Flower Mound	217	198	62	183	65	65	70	228	168	190	173	205	233
Glenn Heights	99	115	107	84	105	100	181	64	111	107	104	95	107
Oak Leaf	206	147	159	155	155	155	155	78	113	111	108	122	111
Grand Prairie	146	153	133	141	125	152	150	168	152	152	143	131	138
Grapevine	229	223	292	216	231	297	297	313	259	304	275	329	324
Hutchins	224	217	189	147	221	231	228	210	204	148	84	96	88
Wilmer	91	97	89	75	87	82	83	101	ND	ND	81	85	84
Irving	209	220	208	194	212	212	234	210	196	193	196	152	158
Lancaster	128	142	139	133	132	122	227	141	107	133	121	118	161
Lewisville	180	167	149	146	152	160	162	165	133	143	136	158	176
Ovilla	177	188	168	154	172	114	230	125	167	154	150	186	223
Red Oak	134	156	151	154	154	148	241	166	133	133	118	113	121
Seagoville	114	132	133	132	143	135	129	83	114	74	107	97	69
The Colony	109	98	98	97	97	97	97	127	105	116	113	130	134
Average gpcd	**178**	**178**	**164**	**155**	**163**	**161**	**192**	**172**	**154**	**158**	**143**	**154**	**165**

[a] Dallas County WCID #6 (DC WCID #6) dissolved during the course of the 2014 Dallas LRWSP and the demands associated with this entity are now listed under Balch Springs.

ND No data reported from source.

Source: http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/index.asp

Table 4-2. Projected gpcd Values for City of Dallas and Customer Cities

Entity	2020	2030	2040	2050	2060	2070
City of Dallas	198	194	191	189	189	189
Addison	369	364	362	361	360	360
Carrollton	166	162	160	158	158	158
Cedar Hill	179	176	174	173	173	173
Cockrell Hill	78	73	71	69	68	68
Combine WSC	102	98	96	95	95	94
Combine	102	98	96	95	95	94
Coppell	237	234	232	230	230	230
Balch Springs [a]	93	89	87	85	85	85
Dallas County-Other	288	288	287	287	286	286
Denton	176	173	170	163	161	161
DeSoto	154	151	149	147	147	147
Duncanville	126	122	119	118	118	118
Farmers Branch	264	260	257	255	255	255
Flower Mound	225	222	221	220	220	220
Glenn Heights	98	95	94	93	93	93
Oak Leaf	103	98	95	94	93	93
Grand Prairie	182	173	169	169	169	169
Grapevine	391	378	375	374	373	373
Hutchins	92	89	88	87	86	86
Wilmer	92	89	86	84	84	84
Irving	192	189	187	185	185	185
Lancaster	152	148	146	146	145	145
Lewisville	168	164	162	161	161	161
Ovilla	213	209	207	206	206	206
Red Oak	133	131	129	128	128	128
Seagoville	98	94	92	91	91	91
The Colony	136	133	131	130	130	130
UTRWD	116	121	123	125	123	122
Dallas Service Area gpcd[a]	**185**	**180**	**176**	**174**	**173**	**171**

[a] Dallas Service Area gpcd is calculated by taking the total water demand projected for all of these entitles (not just the portion provided by Dallas) in gallons divided by the total system population divided by 365 days.

Source: 2016 Region C data as of September 12, 2014.

Table 4-3 shows that in 2020, total demand of Dallas and its customers is projected to be 468.8 million gallons per day (MGD). About 93.2 percent of the total demand comes from Dallas' retail and customer city demand. Other uses such as manufacturing, mining, irrigation and steam-electric power generation will make up the remaining 6.8% or 31.8 MGD. By 2070, total use is expected to be approximately 717.8 MGD with 94.7 percent of the demand coming from the municipal demand on the system. The non-municipal use types make up only 5.3 percent or 37.8 MGD of the total demand. Figure 4-2 illustrates this information graphically. The City of Dallas projected demand in 2020 is 245.6 MGD or 52.4 percent of the total demand on the system. By 2070, the City of Dallas projected demand is 359.3 MGD or 50.1 percent of the total demand on the system.

Table 4-3. Water Demand Projections for the City of Dallas and its Customers

Table units: MGD

DWU System	2020	2030	2040	2050	2060	2070
City of Dallas	245.6	260.8	291.6	322.5	347.2	359.3
Customer Cities	191.4	208.9	230.3	254.6	293.4	320.7
Non-Municipal Demand	31.8	33.8	35.8	37.4	37.6	37.8
Total Demand	**468.8**	**503.5**	**557.7**	**614.5**	**678.2**	**717.8**

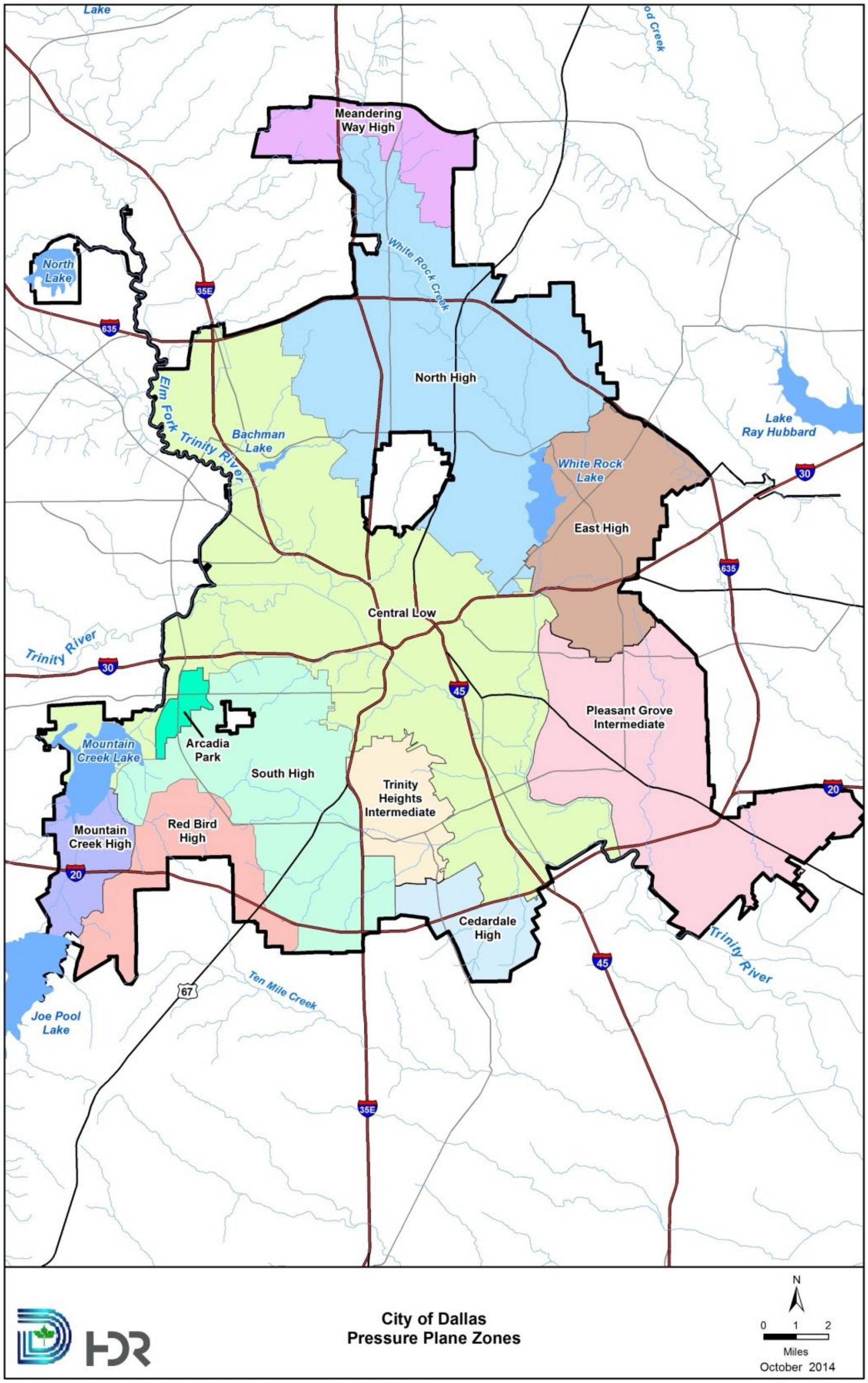
Source: 2016 Region C data as of September 12, 2014.

Table 4-4. Water Demand Projections for City of Dallas (by Major Pressure Planes)

Table units: MGD

Dallas – Major Pressure Plan	2020	2030	2040	2050	2060	2070
Arcadia Park	0.6	0.8	0.9	1.1	1.3	1.4
Cedar Dale High	1.3	2.6	3.4	4.4	5.4	6.2
Central Low	69.7	71.2	78.3	85.2	92.4	95.4
East High	18.3	17.1	17.2	17.1	16.5	15.3
Meandering Way High	15.8	14.9	15.2	15.4	15.1	14.2
Mountain Creek High	4.4	4.8	7.2	9.3	11.3	12.8
North High	87.8	98.2	112.0	126.0	136.0	142.0
Pleasant Grove Intermediate	13.4	13.4	14.7	15.9	16.7	17.0
Red Bird High	7.9	9.5	11.9	14.3	16.5	18.1
South High	21.6	23.8	26.2	29.2	31.6	32.8
Trinity Heights Intermediate	4.8	4.5	4.6	4.6	4.4	4.1
City of Dallas Total	**245.6**	**260.8**	**291.6**	**322.5**	**347.2**	**359.3**

Figure 4-1. Major Pressure Planes for City of Dallas



W:\100834\LRWSP\GIS\map docs\arcmap\Dallas Pressure Planes 092914.mxd - October 2014

Table 4-5. Water Demand Projections for DWU Non-Municipal Customers

Table units: MGD

Entity	2020	2030	2040	2050	2060	2070
Collin County Irrigation	1.6	1.6	1.6	1.6	1.6	1.6
Dallas County Irrigation	0.4	0.4	0.4	0.4	0.4	0.4
Dallas County Manufacturing	24.3	26.4	28.4	30.0	30.2	30.4
Dallas County Mining	0.3	0.2	0.2	0.2	0.2	0.2
Dallas County Steam Electric (TXU)	4.5	4.5	4.5	4.5	4.5	4.5
Denton County Irrigation	0.4	0.4	0.4	0.4	0.4	0.4
Denton County Manufacturing	0.1	0.1	0.1	0.1	0.1	0.1
Rockwall County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Total Non-Municipal Demand	**31.8**	**33.8**	**35.8**	**37.4**	**37.6**	**37.8**

Source: 2016 Region C data as of September 12, 2014.

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

Table units: MGD

DWU System	2020	2030	2040	2050	2060	2070
City of Dallas (Table 4-4)	245.6	260.8	291.6	322.5	347.2	359.3
DWU Non-Municipal Customer (Table 4-5)	31.8	33.8	35.8	37.4	37.6	37.8
DWU Municipal Customer (Table 4-7)	191.4	208.9	230.3	254.6	293.4	320.7
Total Customer Demand	**223.2**	**242.7**	**266.1**	**292.0**	**331.0**	**358.5**
Total Demand	**468.8**	**503.5**	**557.7**	**614.5**	**678.2**	**717.8**
Percent of Total Demand from Customers	**47.6%**	**48.2%**	**47.7%**	**47.5%**	**48.8%**	**49.9%**

Source: 2016 Region C data as of September 12, 2014.

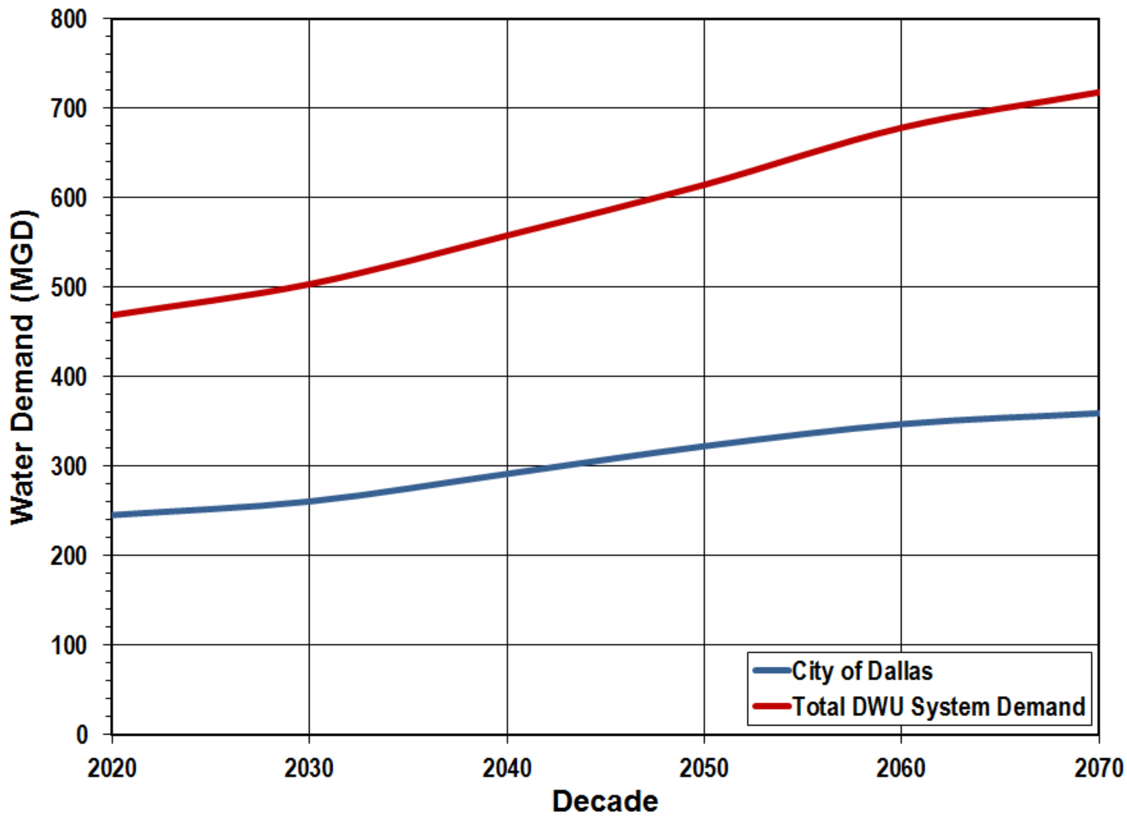
Table 4-7. Water Demand Projections for DWU Municipal Customers

Table units: MGD

Entity	2020	2030	2040	2050	2060	2070
Addison	5.4	6.3	7.3	8.4	9.4	10.4
Carrollton	21.0	21.0	20.6	20.4	20.4	20.4
Cedar Hill	9.3	11.3	13.2	15.2	15.2	15.2
Cockrell Hill	0.4	0.4	0.4	0.4	0.5	1.0
Combine WSC	-	-	-	-	-	-
Combine	0.3	0.3	0.4	0.4	0.5	0.6
Coppell	9.8	10.0	9.9	9.9	9.9	9.9
Balch Springs	2.5	2.6	2.7	2.9	3.2	3.4
Dallas County-Other [a]	0.8	0.4	0.3	0.3	0.3	0.3
Denton	0.0	1.9	8.8	20.3	40.3	56.7
DeSoto	8.4	9.0	9.7	10.5	11.3	12.2
DFW Airport	2.6	2.8	3.1	3.4	3.8	4.1
Duncanville	5.4	5.7	5.6	5.5	5.5	5.5
Farmers Branch	8.1	8.4	8.8	9.3	9.8	10.4
Flower Mound	7.6	7.8	7.8	7.8	7.8	7.8
Glenn Heights	1.5	2.1	2.6	3.2	3.9	5.3
Oak Leaf	0.1	0.1	0.1	0.2	0.3	0.4
Grand Prairie	19.6	27.8	30.4	30.3	29.9	30.0
Grapevine	3.1	3.4	3.4	3.3	3.1	3.0
Hutchins	0.9	1.2	1.6	1.9	2.3	2.6
Wilmer	0.4	0.4	0.6	1.2	1.8	3.4
Irving	15.3	4.5	4.5	4.5	4.5	4.5
Lancaster	6.8	8.6	10.1	11.2	12.3	13.5
Lewisville	19.1	21.9	24.9	27.9	30.8	30.8
Ovilla	1.0	1.2	1.5	1.8	2.2	4.1
Red Oak	0.1	0.1	0.4	0.7	0.9	1.7
Seagoville	1.8	2.2	2.5	2.8	3.2	3.2
The Colony	5.9	5.9	6.2	6.7	6.5	6.3
UTRWD	34.2	41.6	42.9	44.2	53.8	54.0
Total Customer Municipal Demand	**191.4**	**208.9**	**230.3**	**254.6**	**293.4**	**320.7**

Source: 2016 Region C data as of September 12, 2014.
[a] Dallas County Other – this is a specified water user group in the Region C RWP which represents unincorporated areas of Dallas County that will likely be annexed by Dallas or one of its customer cities at some point in the future.

Figure 4-2. Water Demand Projections for the City of Dallas and its Customers



4.4.1 Comparison of Gallons per Capita per Day Projections

A comparison of the gpcd projections for the entire DWU service area from the 2005 Dallas LRWSP, 2011 Region C RWP, and this 2014 LRWSP are shown in Figure 4-3 and in tabular form in Table 4-8. It should be noted that a gpcd was not calculated for some of DWU's customers in the 2005 LRWSP, so the gpcd shown for the 2005 LRWSP is an approximation only; although, it is still useful for comparison purposes. The gpcd's from the 2005 LRWSP and the 2011 Region C RWP are very similar with only slight differences in most decades. However, as shown, the gpcd values used in the 2014 LRWSP are substantially lower than the previous plans. In most decades (2030 – 2060), the 2014 gpcd values are about 34-35 gpcd lower than the previous plans. In 2040, this amounts to a reduction in gpcd of 16.6 percent compared to the 2005 LRWSP. While this is a significant reduction in gpcd, the City of Dallas generally agreed with the lower TWDB values due to changing customer behavior and realizing conservation savings. These reduced gpcd values directly relate to the lower water demands developed for the 2014 LRWSP when compared to previous planning efforts.

Figure 4-3. Comparison of gpcd Projections – 2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

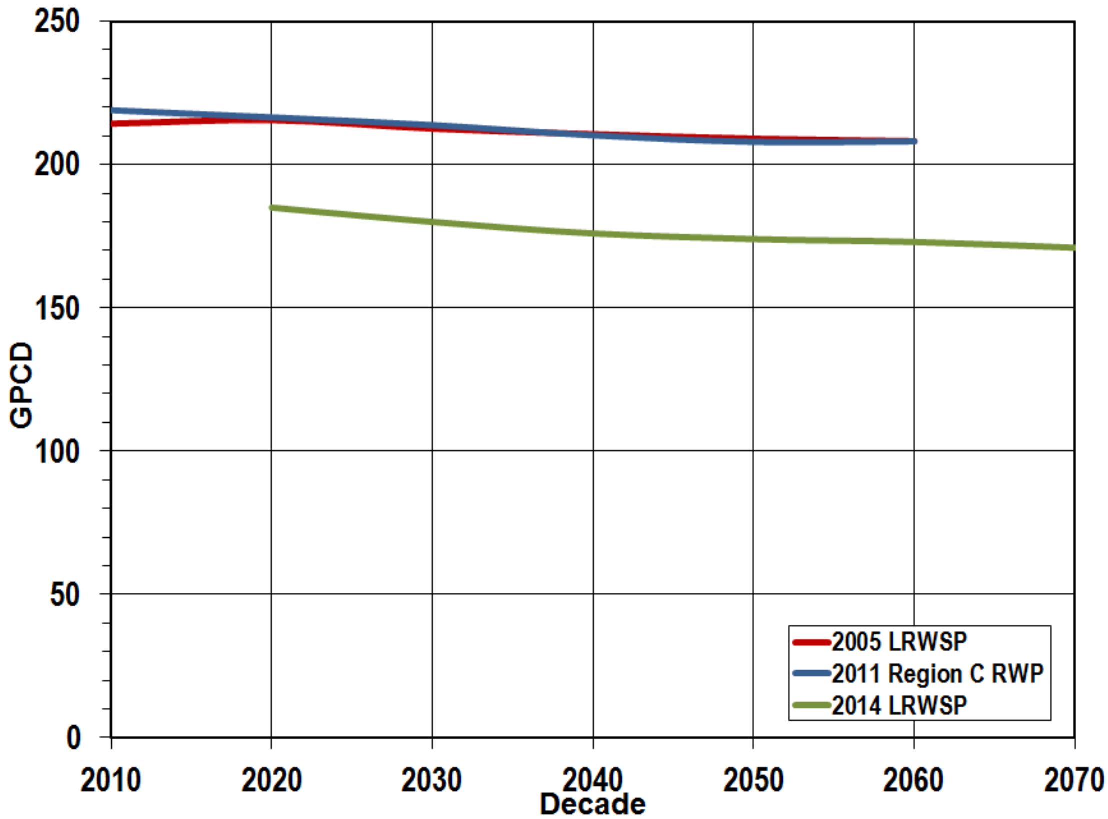


Table 4-8. Comparison of gpcd Projections – 2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

Dallas gpcd Projection	2010	2020	2030	2040	2050	2060	2070
2011 Region C RWP	219	216	214	210	208	208	-
2005 LRWSP Update	214	216	213	211	209	208	-
2014 LRWSP	-	185	180	176	174	173	171
Percent Difference between the 2005 and 2014 LRWSP	-	(14.4%)	(15.5%)	(16.6%)	(16.7%)	(16.8%)	-

4.4.2 Comparison of Water Demand Projections

Water demand projections for the DWU system used in this 2014 LRWSP are compared with demands from both the 2005 Dallas LRWSP and the 2011 Region C RWP in Figure 4-4 and Table 4-11. These demands represent the anticipated demands to be placed on the DWU system after accounting for entities with multiple sources of water. As shown in Figure 4-4, water demands for both the 2005 LRWSP and the 2011 Region C RWP are similar. However, the water demand projections for the 2014 LRWSP are substantially lower. As discussed above, this is primarily due to the much lower per capita values used in the 2014 LRWSP. In 2020, the 2014 LRWSP water demand projections are 104.2 MGD lower than the 2005 LRWSP projections (a 18.2 percent decrease), in 2040, the 2014 LRWSP water demand projections are 150.3 MGD lower than the 2005 LRWSP projections (a 21.2 percent decrease). Finally, in 2060, the 2014 LRWSP water demand projections are 122.8 MGD lower than the 2005 LRWSP projections (an 8.9 percent decrease). Appendix E contains a detailed water demand comparison of the 2014 LRWSP to the 2005 LRWSP and the 2011 Region C RWP for each of Dallas' customer cities.

Figure 4-4. Comparison of Water Demand Projections – 2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

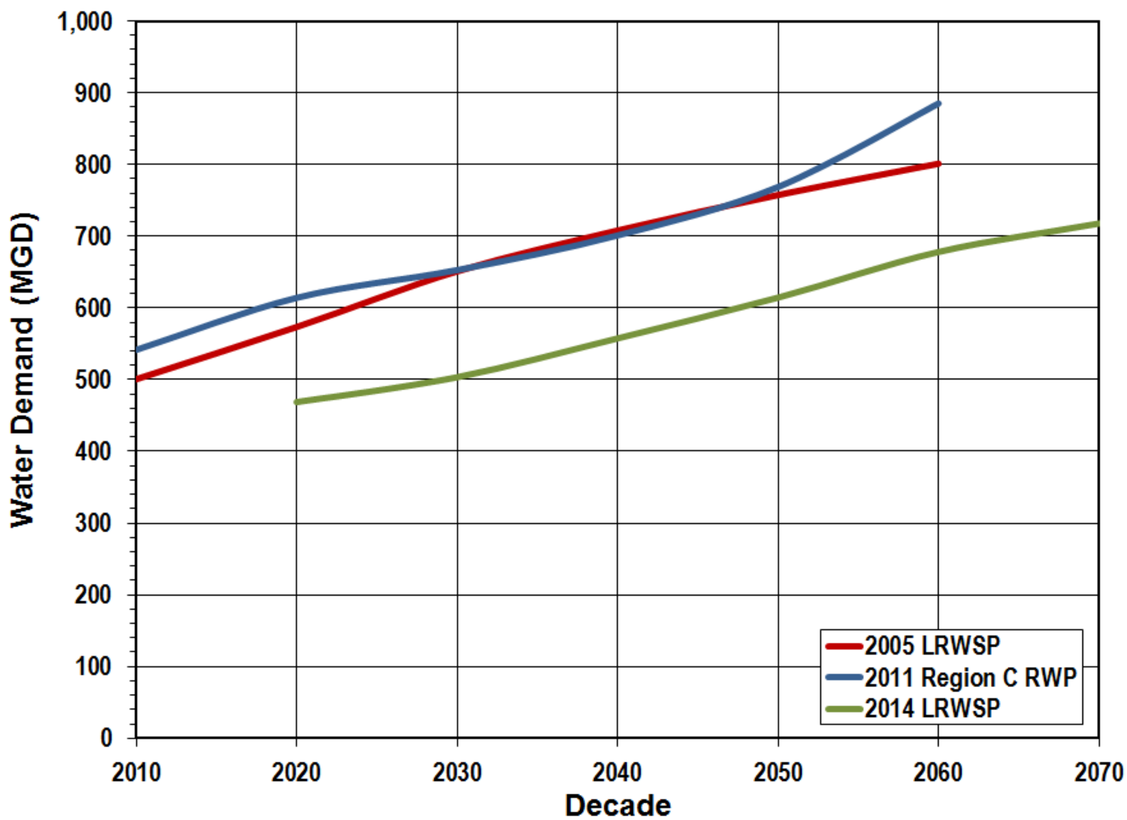


Table 4-9. 2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

Table units: MGD

Dallas Demand Projection	2010	2020	2030	2040	2050	2060	2070
2011 Region C RWP	542	614	653	701	769	885	-
2005 LRWSP Update	501	573	651	708	758	801	-
2014 LRWSP	-	468.8	503.5	557.7	614.5	678.2	717.8
Percent Difference between the 2005 and 2014 LRWSP	-	(18.2%)	(22.7%)	(21.2%)	(18.9%)	(15.3%)	-

4.4.3 Treated Water Demand Projections

DWU provides both treated water and untreated water to its customers. Table 4-10 shows that the total treated water projected to be supplied by DWU to its retail customers and customer cities in 2020 is 381.7 MGD, increasing to 548.3 MGD by 2070 (a 43.6 percent increase). This volume does not include providing treatment services to the City of Irving. Dallas has a contract with Irving to treat all of its water, but is only responsible for providing a small portion of this supply, shown below in the table. Note that the 2016 Region C RWP shows Irving developing additional supplies in the 2020 to 2030 decade, thus reducing demand on Dallas to 4.5 MGD.

Table 4-11 shows the treated water demand for the non-municipal customers served by DWU. This demand totals 26.0 MGD in 2020, increasing to only 32.0 MGD in 2070. Table 4-12 presents the total treated water demand for three groups: City of Dallas, Dallas customer cities, and non-municipal customers. Over the planning horizon, just over 38 percent of Dallas' total treated water demand comes from its customers.

Table 4-10. Treated Water Demand Projections for DWU and its Customers

Table units: MGD

Entity	2020	2030	2040	2050	2060	2070
City of Dallas	245.6	260.8	291.6	322.5	347.2	359.3
Addison	5.4	6.3	7.3	8.4	9.4	10.4
Carrollton	21.0	21.0	20.6	20.4	20.4	20.4
Cedar Hill	9.3	11.3	13.2	15.2	15.2	15.2
Cockrell Hill	0.4	0.4	0.4	0.4	0.5	1.0
Combine WSC	-	-	-	-	-	-
Combine	0.3	0.3	0.4	0.4	0.5	0.6
Coppell	9.8	10.0	9.9	9.9	9.9	9.9
Balch Springs	2.5	2.6	2.7	2.9	3.2	3.4
Dallas County-Other	0.8	0.4	0.3	0.3	0.3	0.3
Denton	0.0	0.0	0.0	0.0	0.0	0.0
DeSoto	8.4	9.0	9.7	10.5	11.3	12.2
DFW Airport	2.6	2.8	3.1	3.4	3.8	4.1
Duncanville	5.4	5.7	5.6	5.5	5.5	5.5
Farmers Branch	8.1	8.4	8.8	9.3	9.8	10.4
Flower Mound	7.6	7.8	7.8	7.8	7.8	7.8
Glenn Heights	1.5	2.1	2.6	3.2	3.9	5.3
Oak Leaf	0.1	0.1	0.1	0.2	0.3	0.4
Grand Prairie	19.6	27.8	30.4	30.3	29.9	30.0
Grapevine	0.0	0.0	0.0	0.0	0.0	0.0
Hutchins	0.9	1.2	1.6	1.9	2.3	2.6
Wilmer	0.4	0.4	0.6	1.2	1.8	3.4
Irving	15.3	4.5	4.5	4.5	4.5	4.5
Lancaster	6.8	8.6	10.1	11.2	12.3	13.5
Lewisville	1.1	3.9	6.9	9.9	12.8	12.8
Ovilla	1.0	1.2	1.5	1.8	2.2	4.1
Red Oak	0.1	0.1	0.4	0.7	0.9	1.7
Seagoville	1.8	2.2	2.5	2.8	3.2	3.2
The Colony	5.9	5.9	6.2	6.7	6.5	6.3
UTRWD	0.0	0.0	0.0	0.0	0.0	0.0
Total Municipal Treated Water Demand	**381.7**	**404.8**	**448.8**	**491.3**	**525.4**	**548.3**

Table 4-11. DWU Treated Water Demand Projections for Non-Municipal Customers

Table units: MGD

Non–Municipal User Group	2020	2030	2040	2050	2060	2070
Collin County Irrigation	0.8	0.8	0.8	0.8	0.8	0.8
Dallas County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Dallas County Manufacturing	24.3	26.4	28.4	30.0	30.2	30.4
Dallas County Mining	0.3	0.2	0.2	0.2	0.2	0.2
Denton County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Denton County Manufacturing	0.1	0.1	0.1	0.1	0.1	0.1
Rockwall County Irrigation	0.1	0.1	0.1	0.1	0.1	0.1
Total Non-Municipal Treated Water Demand	**26.0**	**28.0**	**30.0**	**31.6**	**31.8**	**32.0**

Table 4-12. DWU Treated Water Demand Summary

Table units: MGD

DWU System	2020	2030	2040	2050	2060	2070
City of Dallas	245.6	260.8	291.6	322.5	347.2	359.3
Municipal Customer Treated Water Demand	136.1	144.0	157.2	168.8	178.2	189.0
Non-Municipal Treated Water Demand	26.0	28.0	30.0	31.6	31.8	32.0
Total Customer Treated Water Demand	**162.1**	**172.0**	**187.2**	**200.4**	**210.0**	**221.0**
Percent of Treated Demand from Customers	**39.8%**	**39.7%**	**39.1%**	**38.3%**	**37.7%**	**38.1%**
Total Treated Water Demand	**407.7**	**432.8**	**478.8**	**522.9**	**557.2**	**580.3**

Source: 2016 Region C data as of September 12, 2014.

4.4.4 Untreated Water Demand Projections

DWU provides untreated water supplies to Denton, Grapevine, Lewisville, the Upper Trinity Regional Water District (UTRWD) and various non-municipal customers including steam-electric power generation. UTRWD is projected to be the largest untreated water customer of DWU. Table 4-13 shows that the total untreated water projected to be supplied by DWU in 2020 is 61.1 MGD, increasing to 137.5 MGD by 2070 (a 125 percent increase). Only customers projected to use untreated water supplies are shown in Table 4-13.

Table 4-13. DWU Untreated Water Demand Summary

Table units: MGD

Municipal Entity	2020	2030	2040	2050	2060	2070
Denton	0.0	1.9	8.8	20.3	40.3	56.7
Grapevine	3.1	3.4	3.4	3.3	3.1	3.0
Lewisville	18.0	18.0	18.0	18.0	18.0	18.0
UTRWD	34.2	41.6	42.9	44.2	53.8	54.0
Total Municipal Untreated Water Demand	**55.3**	**64.9**	**73.1**	**85.8**	**115.2**	**131.7**
Non-Municipal						
Collin County Irrigation	0.8	0.8	0.8	0.8	0.8	0.8
Dallas County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Dallas County Steam Electric (TXU)	4.5	4.5	4.5	4.5	4.5	4.5
Denton County Irrigation	0.2	0.2	0.2	0.2	0.2	0.2
Rockwall County Irrigation	0.1	0.1	0.1	0.1	0.1	0.1
Total Non-Municipal Untreated Water Demand	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**	**5.8**
Total Untreated Water Demand	**61.1**	**70.7**	**78.9**	**91.6**	**121.0**	**137.5**

Source: 2016 Region C data as of September 12, 2014.

4.4.5 Demands for DWU Customers with Multiple Sources of Supply

Table 4-14 lists 15 of DWU's current customers that have or are expected to have other sources of supply by 2070. These entities are not expected to rely 100 percent on the Dallas System to meet its future demands. Supply allocations to each of these customers are estimated for existing and future sources of supply based on allocations provided by the Region C RWPG consultants. As future sources of supply become available to these entities, the demands on the Dallas system will likely need to be adjusted accordingly.

Table 4-14 shows that the combined 2070 supply that these customers are expected to obtain from Dallas is approximately 205 MGD and that approximately 218 MGD will be obtained from non-DWU sources. Table 4-14 also shows that five of these customers rely only on small quantities of groundwater in addition to its DWU supplies.

Table 4-14. DWU Municipal Customers with Multiple Water Sources

Table Units: MGD, except as noted

Customer	2070 Demand	% of 2070 Demand Supplied by DWU	2070 Demand Supplied by DWU	2070 Demand Supplied from non-DWU Sources	2070 Demand Supplied by Groundwater [a]
Lancaster	13.6	99.3%	13.5	0.1	0.0
Cedar Hill	15.4	98.7%	15.2	0.2	0.2
Glenn Heights	5.5	96.4%	5.3	0.2	0.2
Oak Leaf [b]	0.4	88.2%	0.35	0.05	0.0
The Colony	8.8	71.6%	6.3	2.5	0.0
Grand Prairie	48.0	62.5%	30.0	18.0	1.2
Denton	91.5	62.0%	56.7	34.8	0.0
Dallas County-Other	0.6	50.0%	0.3	0.3	0.2
UTRWD [c]	115	47.0%	54.0	61.0	0.0
Flower Mound	20.4	38.2%	7.8	12.6	0.0
DFW Airport	15.3	26.8%	4.1	11.2	0.0
Red Oak	6.4	26.6%	1.7	4.7	0.5
Grapevine	22.4	13.4%	3.0	19.4	0.0
Irving	52.6	8.6%	4.5	48.1	0.0
Totals	**415.9**		**202.75**	**213.15**	**2.3**

Source: 2016 Region C data as of September 12, 2014.

[a] Total groundwater supply shown is from the Trinity and Woodbine Aquifers. This total is already included in the total in the previous column.

[b] Approximately 11.8% of Oak Leaf's supply comes from other sources. This is approximately 0.0472 MGD. This value rounded in the table to the nearest 0.01 MGD.

[c] Some of UTRWD's customers may have groundwater supplies; however UTRWD does not utilize groundwater as a supply.

4.5 Historical Dallas Water Demand and the Impacts of Conservation

Dallas has achieved considerable savings in water demand by lower per capita use since conservation efforts began in earnest in the early 2000's. Dallas routinely experienced gpcd rates above 240 and as high as 280 in the late 1990's. Dallas has been able to mitigate the impact of drought weather conditions on water supply.

Figure 4-5 illustrates these historical values and shows the impacts of Dallas' conservation efforts on reducing the gpcd values. The impact of conservation on water demand can be seen in the differences portrayed by the light blue area on the figure which represents the projected water use by Dallas without conservation. For example, in 2011 Dallas achieved over a 20 percent savings in water use from conservation. This is significant, especially since 2011 represents the hot, dry year that the TWDB projections are based upon for the 2016 Region C RWP. The red line on the graph representing Dallas' conservation goal shows two key things. The first is that Dallas has exceeded its use goal 4 out of 8 years since the initial goal was set in 2005. Second is that the trend of this line is down, meaning that Dallas anticipates realizing even more savings from conservation with a 1.5 percent per year goal in the near future. The downward trend shows that Dallas anticipates realizing additional savings from conservation (Additional Conservation in Section 7) above what the TWDB estimates from the realization of savings from the Plumbing Fixtures Act (Figure 4-3).

The following items are key facts regarding Dallas' successful water conservation plan.

- Dallas saved through FY 2013 an estimated 250 billion gallons of water since 2001.
- Dallas gpcd has been reduced approximately 26 percent from FY01 to FY14.
- Dallas has been able to mitigate the impact of drought weather conditions on water supply.
- Since implementation of the Twice Weekly Watering Program in April 2012, water consumption is 5-6 percent lower.
- Non-watering days have 25 to 40 MGD less demand, an average of 8 percent less than watering days.
- Implementation of "time of day" watering has helped Dallas reduce peak demand on the system.

Figure 4-5. Recent Per Capita Water Consumption and Goals

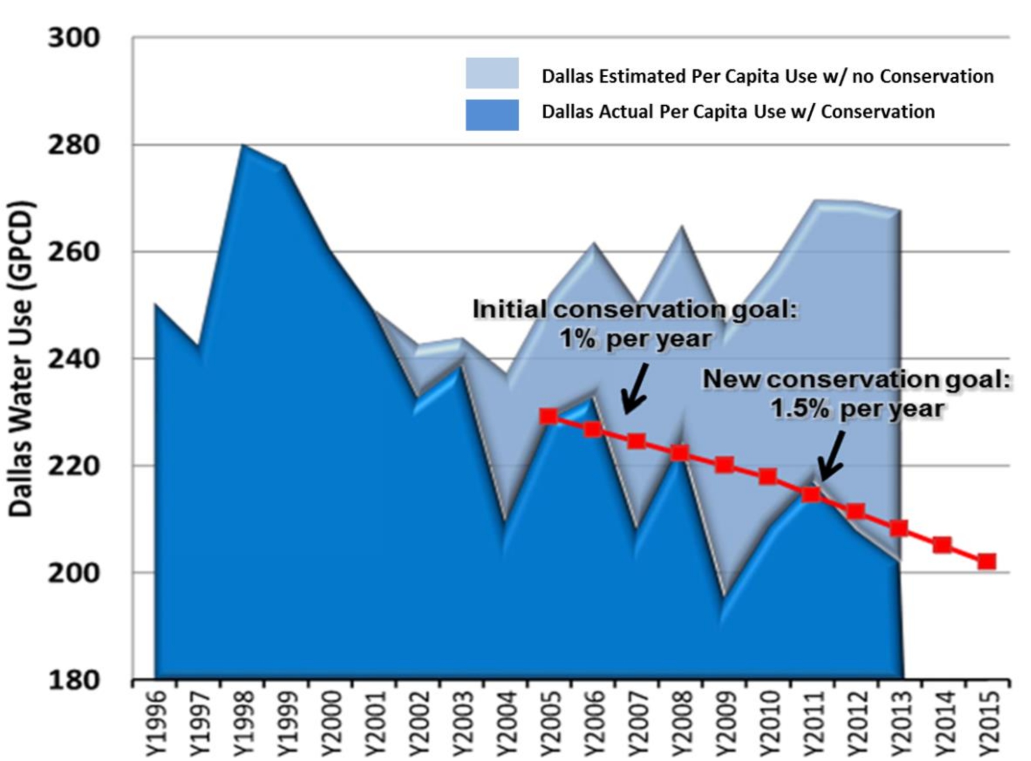


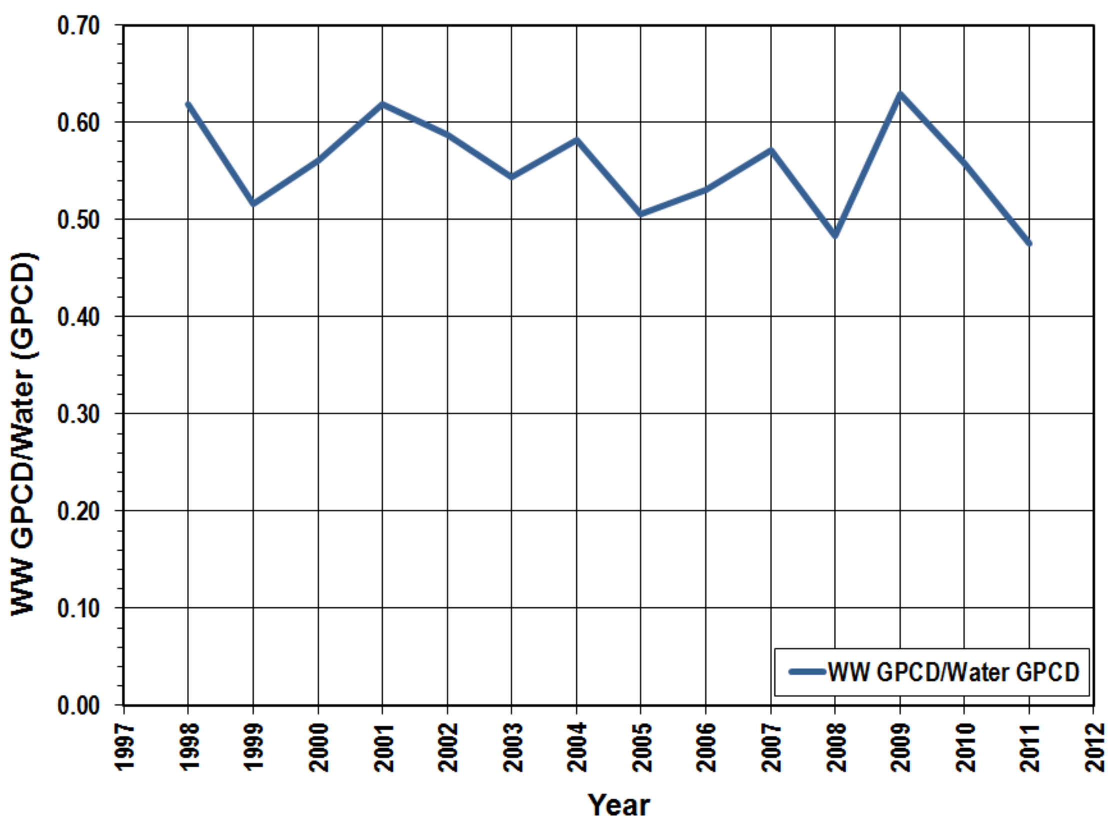
Figure Source: Dallas Water Utilities Water Conservation Program

4.6 Wastewater Effluent Projections

This section discusses the historic and future estimates of total treated effluent discharge from DWU's two wastewater treatment plants: Central Wastewater Treatment Plant (CWWTP) and South Side Wastewater Treatment Plant (SSWWTP). Population projections were utilized with historical water and wastewater gallons per capita per day (gpcd) data to estimate projected treated effluent discharges by decade through 2070. Wastewater flow data from Dallas' wastewater treatment plants were only available through 2011 at the time this analysis was being performed. This section relies on this data and from a previous report titled "Wastewater Treatment Facilities Strategic Plan", Carollo Engineers, Inc., 2010 (2010 WW Strategic Plan).

After the historical water and wastewater gpcd values were determined, a ratio of the wastewater gpcd to the water gpcd was calculated as shown in Figure 4-6 and Table 4-15. The last five years of this data (2007-2011) was used to determine a reasonable estimate of a future return flow ratio, as this period captures both wet and dry year conditions and recent DWU water conservation accomplishments. The five-year average ratio was determined to be 0.54, which means that, on average, the wastewater gpcd is 54 percent of the water gpcd. This averaged value was then used to forecast future wastewater gpcd values based on projected water gpcd values through the planning period. Using projected population data developed for this 2014 LRWSP, these wastewater gpcd values were used to estimate future average annual wastewater flow (AAWF).

Figure 4-6. Ratio of Wastewater gpcd and Water gpcd for 1998 to 2011 Period



4.6.1 Background Data and Projection Methodology

Historical treated effluent discharge data was obtained for a 14 year period from 1998 to 2011 from DWU effluent flow records (Figure 4-7 and Table 4-15) and, in part, from the 2010 WW Strategic Plan. The data indicates that AAWF at both the CWWTP and SSWWTP have recently been declining due, in part to Dallas' water conservation initiatives, with peak day flows being relatively steady. The 2010 WW Strategic Plan also indicated that the current flow split is approximately 64 percent to CWWTP and 36 percent to SSWWTP based on AAWF.

Historical water use data was obtained from the TWDB over the same time period as the available wastewater data. Historical population estimates over this time period were also developed using TWDB data originating from the U.S. Census Bureau. Note that Dallas' wastewater service area / population is different than its water service area / population. These data were used to calculate a historical use rate in gpcd for both the wastewater consumption and the water consumption (Table 4-15 and Figure 4-7).

Average annual dry-weather wastewater flows (ADWF) were projected in addition to the AAWF. The ADWF was calculated in the 2010 WW Strategic Plan for each year by omitting flows on days when significant rainfall events occurred and during subsequent days when flows were elevated. In order to project the ADWF, a ratio of AAWF to ADWF was determined using historical data developed as part of the 2010 WW Strategic Plan. The 2010 WW Strategic Plan only provided historical dry-weather wastewater flows for years 2000 through 2008 (Table 4-16). A ratio of dry-weather flows to average annual flows was calculated over this time period. Table 4-16 shows that ADWF during this nine year period averaged a ratio of 0.9296 of the AAWF. The data in Table 4-16 are shown to more than three significant figures to compute a more precise ADWF/AAWF ratio. Figure 4-8 shows a plot of the dry-weather factors over time and no trend in this ratio was determined to be significant. Estimates of future ADWF were determined by multiplying future AAWF estimates by the 0.9296 ratio.

Currently, a small portion of Dallas treated water customers are served by the Trinity River Authority (TRA) for wastewater service. It is estimated that as much as 6.3 MGD of Dallas supply based effluent is treated and then discharged by the TRA. Dallas has expressed an interest in recovering this effluent and being able to utilize these flows as part of its indirect reuse strategies. This recovery of effluent would involve infrastructure improvements to transport the water to either Dallas' Central or Southside WWTPs.

Table 4-15. Summary of Historical Water Use, Treated Wastewater Flows, and Water and Wastewater Per Capita Use Rates for DWU's Wastewater Customers (1998 to 2011)

Table units: as specified in table

Year	Population [a]	Water Use [b] (MGD)	Wastewater Flow, AAWF [c] (MGD)	Water Use (gpcd)	Wastewater Flow (gpcd)	Ratio of: WW gpcd/Water gpcd
1998	1,519,418	349.4	216.1	230	142	0.62
1999	1,523,788	399.4	206.1	262	135	0.52
2000	1,528,157	386.2	216.4	253	142	0.56
2001	1,532,526	370.6	229.0	242	149	0.62
2002	1,536,896	365.0	214.4	237	140	0.59
2003	1,541,265	359.8	195.6	233	127	0.54
2004	1,545,635	360.4	209.6	233	136	0.58
2005	1,550,004	368.7	186.5	238	120	0.51
2006	1,554,373	346.7	184.0	223	118	0.53
2007	1,558,743	348.7	199.1	224	128	0.57
2008	1,563,112	332.8	161.0	213	103	0.48
2009	1,567,482	279.9	176.1	179	112	0.63
2010	1,571,851	297.4	166.1	189	106	0.56
2011	1,576,220	301.3	143.0	191	91	0.47
5-Year Average (2007 – 2011)				199	108	0.54

[a] Historical population values for DWU's wastewater customers estimated from 2000 and 2010 Census Data. Intervening years were interpolated from those two historical values.

[b] Historical water use values were obtained from the TWDB through the Annual Water Use Surveys.

[c] Wastewater flows from DWU treated wastewater effluent records.

Figure 4-7. Historical Water Use, Treated Wastewater Flows and Water and Wastewater Per Capita Use Rates for DWU Wastewater Customers (1998 to 2011)

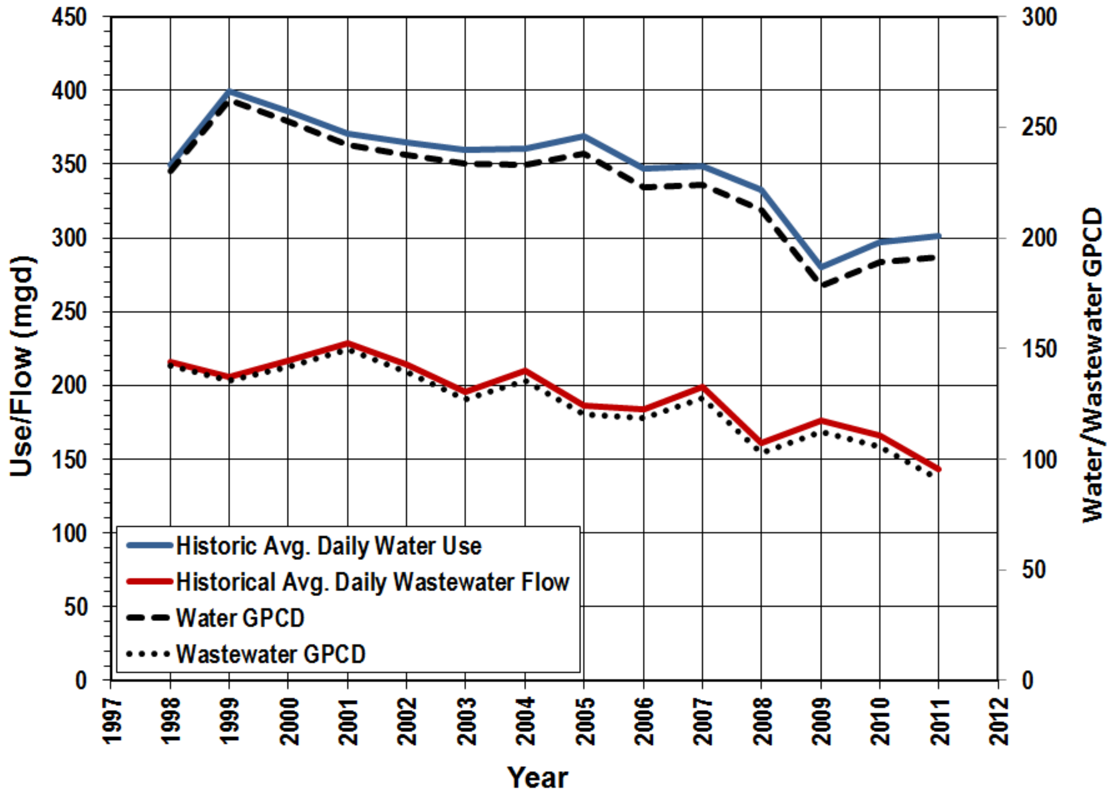


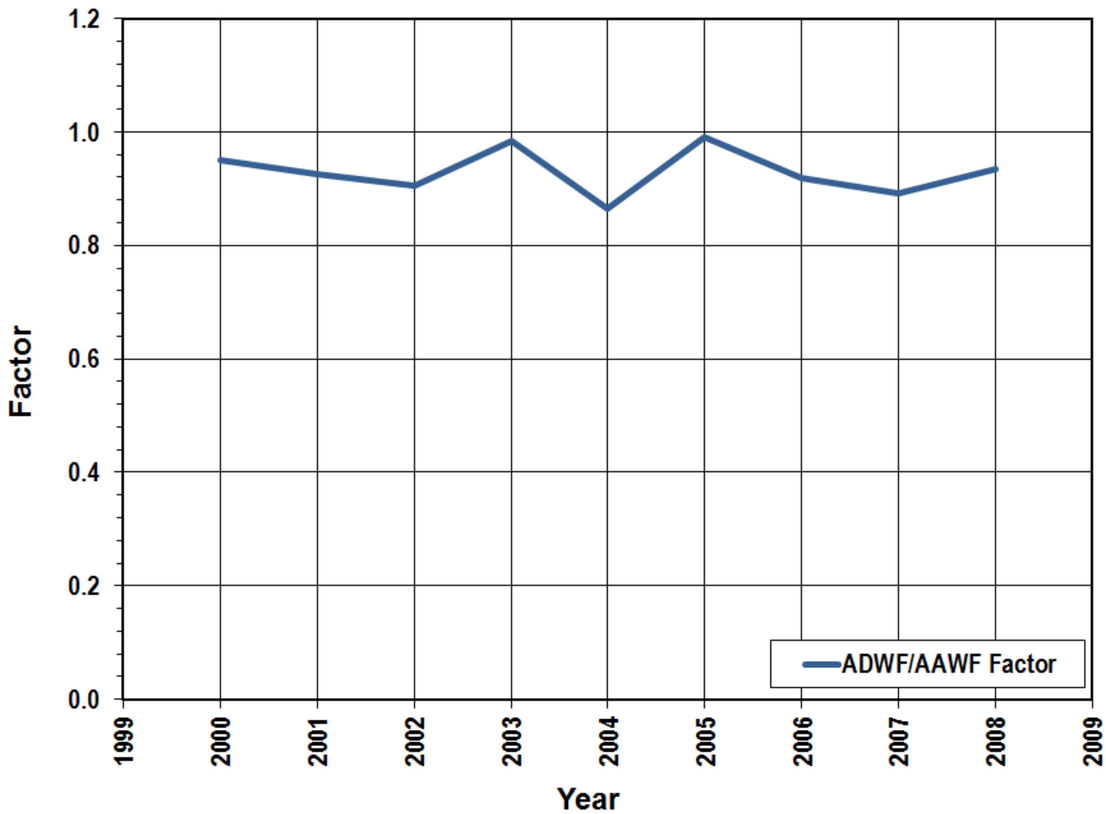
Table 4-16. Ratio of Historical Dry-Weather Wastewater Flows (ADWF) and Average Annual Wastewater Flows (AAWF) discharged from Dallas' Central and Southside WWTPs

Table units: MGD

Year	Wastewater Flow, AAWF [a]	Wastewater Flow, ADWF [b]	ADWF/AAWF Factor
2000	216.4	205.5	0.9496
2001	229.0	212.2	0.9266
2002	214.4	194.0	0.9049
2003	195.6	192.4	0.9836
2004	209.6	181.4	0.8655
2005	186.5	184.9	0.9914
2006	184.0	168.9	0.9179
2007	199.1	177.5	0.8915
2008 [c]	161.0	150.6	0.9354
Average Ratio			0.9296

[a] AAWF flow values from DWU treated effluent records.
[b] ADWF flow values calculated in the 2010 WW Strategic Plan.
[c] Data were only available through 2008 from the 2010 WW Strategic Plan.

Figure 4-8. Ratio Factor of Historical Dry-Weather Wastewater Flows (ADWF) and Average Annual Wastewater Flows (AAWF) for 2000 to 2008 Period



4.6.2 Population Projections for City of Dallas Wastewater Customers

Population projections for the City of Dallas and its wastewater customers are shown in Table 4-17. These projections show that by 2020, the total population of the DWU wastewater service area will be 1,653,367, while the City of Dallas population will be 1,242,135 (or 75.1 percent of the total wastewater service area population). In 2070, the total population of the DWU wastewater service area is projected to be 2,528,658, while the City of Dallas population is projected to be 1,905,498 (or 75.4 percent of the total wastewater service area population). These population projections were used to determine the projected water and wastewater per capita rates for the DWU wastewater service area.

Table 4-17. Population Projections for Dallas and DWU Wastewater Customer Cities

Table units: number of people

Customer City [a]	2020	2030	2040	2050	2060	2070
Addison	14,539	17,431	20,323	23,215	26,107	29,000
Balch Springs	26,423	28,980	31,606	34,456	37,233	40,018
Cockrell Hill	4,670	5,122	5,122	5,122	7,000	15,000
Dallas	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498
Duncanville	42,927	47,106	47,106	47,106	47,106	47,106
Highland Park	9,025	9,313	9,313	9,313	9,313	9,313
Hutchins	9,903	13,922	17,941	21,960	25,979	30,000
Mesquite	150,000	165,000	186,335	203,156	219,576	236,034
Richardson	105,000	108,200	112,500	116,000	116,000	116,000
Seagoville	18,854	22,873	26,892	30,911	35,000	35,000
University Park	25,688	25,688	25,688	25,688	25,688	25,688
Wilmer	4,203	4,698	7,500	14,000	22,000	40,000
Total Population	**1,653,367**	**1,796,050**	**2,022,007**	**2,237,984**	**2,412,066**	**2,528,657**

[a] Population projection numbers from 2016 Region C RWP.

4.6.3 Water Demand and gpcd Projections for Dallas Wastewater Customers

Future estimates of water demands for Dallas' wastewater customers were used in conjunction with the population projections above to determine a projected gpcd value for each decadal point during the planning period. These gpcd values were then multiplied by the ratio of wastewater gpcd to water gpcd to determine a projected wastewater gpcd as described in Section 4.5.1. Projected water demands are shown for each customer city in Table 4-18 as well as the projected gpcd values for the customers as a whole. This data shows that in 2020 these customers will use a total of 316.7 MGD of water and by 2070 will use 454.2 MGD. It is important to note that the gpcd values decrease over time due to anticipated water savings from low flow plumbing fixtures. No other additional water conservation was assumed to occur over the projection period for the purposes of this analysis.

Table 4-18. Water Demand Projections for Dallas and DWU Wastewater Customer Cities

Table units: MGD

Customer City [a]	2020	2030	2040	2050	2060	2070
Addison	5.4	6.4	7.4	8.4	9.4	10.4
Balch Springs	2.5	2.6	2.7	2.9	3.2	3.4
Cockrell Hill	0.4	0.4	0.4	0.4	0.5	1.0
Dallas	246	261	292	323	348	360
Duncanville	5.4	5.7	5.6	5.6	5.5	5.5
Highland Park	3.6	3.7	3.7	3.7	3.7	3.7
Hutchins	0.9	1.2	1.6	1.9	2.3	2.6
Mesquite	20.0	21.3	23.5	25.4	27.4	29.4
Richardson	23.5	23.8	24.4	25.0	25.0	25.0
Seagoville	1.8	2.2	2.5	2.8	3.2	3.2
University Park	6.8	6.7	6.6	6.6	6.6	6.6
Wilmer	0.4	0.4	0.6	1.2	1.9	3.4
Total Water Demand (MGD)	**316.7**	**335.4**	**371.0**	**406.9**	**436.7**	**454.2**
gpcd	**192**	**187**	**183**	**182**	**181**	**180**

[a] Population projection numbers from 2016 Region C RWP as of September 12, 2014.

4.6.4 Wastewater Effluent Projections

Projections of effluent for DWU wastewater customers were developed for the 2020 to 2070 timeframe for both the AAWF and ADWF as described in the following sections. The AAWF accounts for both wet-weather and dry-weather periods while the ADWF is based on dry-weather periods only.

Annual Average Wastewater Flow Projections

A ratio of 54 percent was developed (as previously shown in Table 4-15) between historical wastewater gpcd values and historical water gpcd values based on the average of these values from 2007 to 2011. This factor was multiplied by the projected water gpcd values to obtain a projected wastewater gpcd value for each decade. These values were then converted to an average annual flow value using the population projections in Section 4.6.2, Table 4-17. The 2010 WW Strategic Plan (which only considered wastewater data through 2009) projected a 2030 average day flow of 197 MGD or 15 MGD higher (about 8 percent) than this study, which considered data through 2011.

Annual Average Dry-Weather Flow Projections

A ratio of 92.96 percent was developed between the historical AAWF and ADWF using annual flow data between 2000 and 2008. This ratio was multiplied by the AAWF to calculate the projected ADWF as shown in Table 4-19 for the 2020 to 2070 timeframe.

Figure 4-9 shows historical and projected water use and wastewater flows based on this analysis.

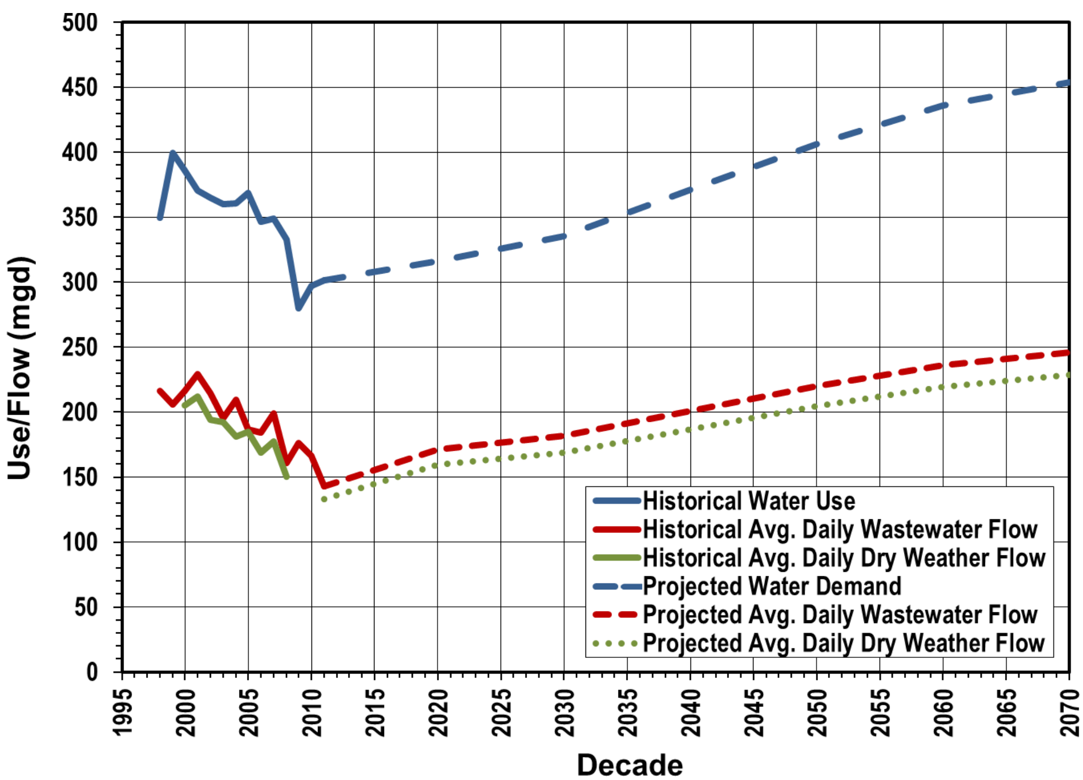
Table 4-19. Estimates of Future Wastewater Flows for DWU Wastewater Customers (2020 to 2070)

Table units: specified in table

Year	Average Annual Per Capita Water Use (gpcd)	Average Annual Per Capita Wastewater Flow [a] (gpcd)	Average Annual Wastewater Flow [b] (MGD)	Average Dry-Weather Wastewater Flow [c] (MGD)
2020	191	104	172	159
2030	187	101	182	169
2040	183	99	201	187
2050	182	98	220	205
2060	181	98	236	220
2070	179	97	246	229

[a] Calculated by multiplying the Average Annual Per Capita Water Use by 54%.
[b] Calculated by multiplying the projected Average Annual Per Capita Wastewater Flow by population.
[c] Calculated by multiplying the Average Annual Wastewater Flow by 92.96%.

Figure 4-9. Historical and Projected Water Use and Wastewater Flows for DWU Wastewater Customers



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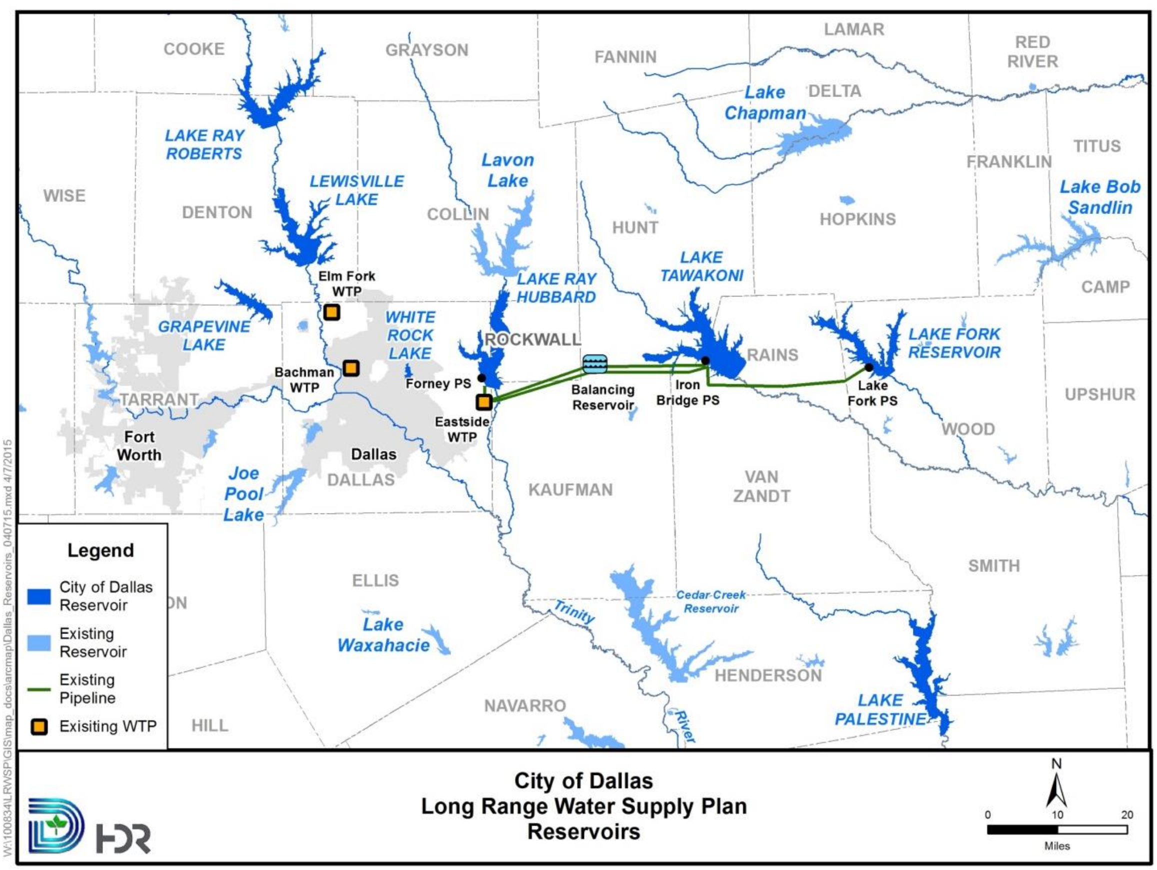
5 Water Rights and Current Supplies

Section 5 presents information on Dallas' water rights, contracted water amounts, and reservoir yields. Certificates of Adjudication (CoA) and/or water rights permits (permit) identify the maximum amounts of water that may be impounded and/or withdrawn from a reservoir or stream. However, water supply planning must also consider the yield of Dallas' system or the amount of water that can be supplied during a repeat of the worst drought on record. Reservoir yields were determined using the Dallas Water Supply Model (RiverWare Model) which considers hydrology and reservoir characteristics.

Dallas' water supply system is composed of seven supply reservoirs located in the Trinity, Sabine, and Neches river basins and run-of-river diversions from the Elm Fork of the Trinity River (Elm Fork). One of these reservoirs (Lake Palestine) is currently not connected to the Dallas system but its yield is discussed in this section. For the purposes of this planning study, Dallas' supply system is divided into western and eastern subsystems to coincide with the demands in Dallas' treatment and distribution system. The western subsystem supplies Dallas' Elm Fork and Bachman water treatment plants (WTPs), and the eastern subsystem supplies the Eastside 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



5.1 Existing Water Rights and Contracts

Table 5-1 presents a summary of Dallas' existing water rights and water rights associated with Dallas contracts for raw water. The information provided in Table 5-1 is based on documents provided by the Texas Commission on Environmental Quality (TCEQ), Dallas staff, and Dallas' water rights attorney (Webb & Webb). Appendix F summarizes additional water rights owned by Dallas that are not used for water supply.

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

Units: as noted in table

Reservoir	River Basin	Reservoir Owner or Permit Holder	Certificate of Adjudication or Permit No.	Priority Date(s)	Dallas Portion of Authorized Diversions MGD (acft/yr)
Western Subsystem					
Lake Grapevine	Trinity	USACE [a]	08-2458 [b]	Jul-1948	75.9 (85,000)
Lake Ray Roberts	Trinity	USACE	08-2455 [c]	Nov-1975 Apr-1990	528.2 (591,704)
Lake Lewisville	Trinity	USACE	08-2456 [d]	Jan-1924 Oct-1948 Nov-1975	491.0 (549,976)
Elm Fork Run-of-River	Trinity	Dallas	CF-75 (08-2457) Permit 5414	Apr-1914 Apr-1984 Apr-1992	54.5 (61,309)
Eastern Subsystem					
Lake Ray Hubbard	Trinity	Dallas	08-2462	Feb-1955	80.1 (89,700)
Lake Tawakoni	Sabine	Sabine River Authority (SRA)	05-4670 [e]	Sep-1955	170.0 (190,480)
Lake Fork	Sabine	SRA	05-4669 [f]	Jun-1974 Feb-1983 Aug-1985	117.7 (131,860) [i]
Others					
White Rock Lake	Trinity	Dallas	08-2461	Apr-1914 Aug-1982	7.8 (8,703)
Lake Palestine	Sabine	UNRMWA [g]	06-3254 [h]	Apr-1956	102.0 (114,337)
Indirect Reuse	Trinity	Dallas	Permit 12468	Dec-2001	220.7 (247,200)

[a] United States Army Corps of Engineers.

[b] CoA 08-2458 is owned by Dallas. The City of Grapevine and DCPC MUD#1 own water rights associated with Lake Grapevine.

[c] CoA 08-2455 is owned by Dallas. The City of Denton owns water rights associated with Lake Ray Roberts. Dallas – Denton split = 74% Dallas – 26% Denton.

[d] CoA 08-2456 is owned by Dallas. The City of Denton owns water rights associated with Lake Lewisville. 95.2% Dallas, 4.8% Denton.

[e] CoA 05-4670 is owned by the SRA and water is contracted to Dallas. 80% Dallas, 20% SRA.

[f] CoA 05-4669 is owned by the SRA and water is contracted to Dallas. 70% Dallas, 30% SRA.

[g] Upper Neches River Municipal Water Authority.

[h] CoA 06-3254 is owned by the UNRMWA and water is contracted to Dallas. Lake Palestine is not currently connected to the DWU system, but is anticipated to be connected to Dallas' western subsystem in the future. 53.73% Dallas, 46.27% UNRMWA.

[i] Only 120,000 acft/yr of the authorized amount (131,860) is available as an inter-basin transfer to the Trinity Basin.

5.1.1 Western Subsystem

For the purposes of this report, Dallas' western subsystem is described as supplying the Elm Fork and Bachman WTPs and includes supplies from Lake Grapevine and the Elm Fork System, which includes Lakes Ray Roberts and Lewisville and run-of-river diversion from the Elm Fork of the Trinity River. Although Lake Palestine is not currently connected to the Dallas system, its yield is discussed in this section.

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). 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. This operating agreement was considered in the yield analyses discussed below.

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). 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.

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). 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.

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 (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 +1,927.8 + 40,000) acft/yr.

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 102.0 MGD (114,337 acft/yr) is contracted to Dallas. Lake Palestine is not currently connected to the Dallas system, but, as discussed later in this plan, Dallas is planning to begin deliveries from this source by about 2030.

5.1.2 Eastern Subsystem

For the purposes of this report, Dallas' eastern subsystem is described as supplying the Eastside WTP and includes supplies from Lake Ray Hubbard, Lake Tawakoni and Lake Fork.

Lake Ray Hubbard

Lake Ray Hubbard 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.

Dallas is currently pursuing a water right permit amendment for Lake Ray Hubbard which will allow for a total annual diversion of 187.0 MGD (209,300 acft/yr). This permit amendment is expected to be approved within the next few years and will allow for greater operational efficiency on Dallas' eastern subsystem by allowing over-drafting from Lake Ray Hubbard when water is available, thereby reducing diversions and pumping costs associated with using water from Lakes Tawakoni and Fork.

Lake Fork

Lake Fork Reservoir (or Lake Fork) is owned by the 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 recently completed a pipeline which connects the reservoir to both Lake Tawakoni and Dallas' Eastside 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.

Lake Tawakoni

Lake Tawakoni is owned by the Sabine River Authority of Texas (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. 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 169.9 MGD (190,480 acft/yr) of raw water and operates a pipeline which connects the reservoir to Dallas' Eastside 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.

5.1.3 White Rock Lake

White Rock Lake is owned by Dallas and is located on White Rock Creek, a tributary of the Trinity River. Reservoir impoundments began September 1911 and the water level first reached conservation pool elevation in August 1912. Dallas has a water right (CoA 08-2461) to impound 21,345 acft of water and divert up to 7.8 MGD (8,703 acft/yr) for municipal, irrigation, and recreational purposes.

As part of the LRWSP, a firm yield analysis was performed for White Rock Lake for 2020 and 2070 sediment conditions. It is estimated that White Rock Lake will have a 2020 conservation storage of 7,132 acft, and this storage will be reduced to 3,304 acft in 2070. The resulting White Rock Lake firm yields for 2020 and 2070 sediment conditions are 2.9 MGD (3,215 acft/yr) and 1.7 MGD (1,895 acft/yr), respectively. White Rock Lake supplies are not considered in the total sum of Dallas supplies in this section.

5.1.4 Dallas Return Flows from Central and Southside Waste Water Treatment Plants

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

Units: as noted in table

Certificate of Adjudication No. or Permit No.	Priority Date	Permitted Use
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.
Application No. 12468A	Dec-2001	Authorizes use of 87.6 miles of the bed and banks in Reach 805 of the Upper Trinity River for the transport and diversion of return flows from Dallas' Central and Southside WWTPs.

At this time, the return flows of the City of Lewisville and the Town of Flower Mound are being diverted and used by Dallas under an Accounting Plan approved by the TCEQ. The total discharge from the Lewisville and Flower Mound WWTPs is currently 11.7 MGD (13,200 acft/yr) or approximately 13.5 percent of the permitted amount. 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 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 CWWTP and SSWWTP 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.

5.1.5 Elm Fork Return Flows available for Dallas diversion

Estimates of return flows available to Dallas were obtained from the 2016 Region C RWP data as of September 12, 2014. Appendix G provides additional information regarding the 2016 Region C RWP return flow estimates available to Dallas which are summarized in Table 5-3. The Dallas Water Supply model (described in Section 5.3) includes the portion of these flows that were being discharged in 2007 and these values are summarized on the bottom part of Table 5-3. The portion of return flows as provided by the 2016 Region C RWP that exceed the 2007 return flows in the Dallas RiverWare model were added as a separate supply source.

Table 5-3. Summary of Elm Fork Return Flows (from 2016 Region C Water Plan as of September 12, 2014)

Table units: MGD

Source	2020	2030	2040	2050	2060	2070
2016 Region C Return Flows						
Lewisville and Flower Mound Return Flows (Includes return flows from 17% of Denton County Manufacturing)	15.8	18.4	19.5	20.9	22.2	22.2
Dallas' share of Denton Return Flows to Lake Lewisville [a]	6.0	7.8	9.7	13.1	22.1	29.5
Dallas' share of UTRWD Return Flows to Lake Lewisville	0.0	0.0	0.0	3.6	5.9	7.0
NTMWD Discharges to Lake Lewisville [b]	6.9	5.6	7.0	7.0	7.0	7.0
Total - 2016 Region C	**28.7**	**31.8**	**36.2**	**44.6**	**57.2**	**65.7**
How Above Return Flows were Modeled in 2014 LRWSP						
2007 Return Flows included in Dallas Water Supply Model and Reservoir Yields	15.4	15.4	15.4	15.4	15.4	15.4
Additional Elm Fork Return Flows not included in Dallas Water Supply Model [c]	**13.3**	**16.4**	**20.8**	**29.2**	**41.8**	**50.3**

[a] Per agreement with Dallas, Denton can use 50% of its WWTP discharges into Lake Lewisville capped at 50% of Denton's firm yield supply in Lakes Lewisville and Ray Roberts. Dallas can use the remaining discharge (as shown) from Denton's WWTP.

[b] Available return flows from NTMWD WWTP discharges to Lake Lewisville may potentially be reduced to 4.57 MGD per the Swap Agreement.

[c] These values are the 2016 Region C Return Flows as of September 12, 2014 and as shown above, less the 2007 Return Flows included in the Dallas Water Supply Model. These values are included in the 2014 LRWSP as a supply source.

5.2 Basis for Reservoir Yields

Reservoir yield calculations were performed using the Dallas Water Supply Model (Dallas model) developed by HDR. The Dallas model utilizes the RiverWare program and includes 101 years of hydrologic data including reservoir inflows from 1907 to 2007 for Dallas' reservoirs. This extended simulation period allows for the comparison of yields associated with droughts that may be more severe than the 1950's drought (1951-1957) which is typically considered the drought of record in most of Texas. Model simulations show that the 1908 drought (1908-1913) is more severe for Dallas' eastern reservoirs including Lake Tawakoni, Lake Fork, and Lake Palestine, and the 1950's drought was more severe for Dallas' western reservoirs. For comparison purposes, both drought firm yields and supplies available to Dallas are presented in Section 5.3.

5.2.1 Yield Analysis Modeling Assumptions

In a multi-reservoir system as complex as Dallas', there are many assumptions that need to be made to appropriately calculate current and future reservoir yields and supplies. Modeling assumptions were reviewed with Dallas staff before model simulations were performed and are detailed herein.

Simulations were performed utilizing the Dallas model to calculate the firm yields of all supply reservoirs during historical drought periods within the 1907-2007 simulation period. ***A firm yield is defined as the annual demand on a reservoir that will not reduce lake levels below the dead pool storage level during a repeat of the most severe historical drought.***

Model simulations were performed under 2020 and 2070 sediment conditions for all reservoirs. Elevation-area-capacity (EAC) relationships for current (year 2020) and future (year 2070) sediment conditions for each reservoir are included in Appendix H and include the conservation pool capacities and dead pool storages used for all model simulations. The current and future EAC relationships and annual average sedimentation rates were extrapolated from 2010 and 2060 EAC relationships used in the 2011 Region C, Region I, and Region D water plans.

Current and future reservoir yields consider projected increases in temperature based on climate model predictions and the associated increases in reservoir evaporation. Climate models predict an increase in average high temperature of 2° Fahrenheit (°F) from historical average high temperatures by 2020 and a 7°F increase from historical average high temperatures by 2070. A more detailed description of climate model projections and associated changes in reservoir evaporation are included in Appendix I.

Return flows available to Dallas using 2007 data are included in the Dallas model and considered in firm yield calculations. Increases in return flows in the Elm Fork of the Trinity River projected to occur after 2007 are not included in reservoir yields. These increases are accounted for as a separate supply as discussed in Section 5.3 and shown in Table 5-3. The increases in return flows in the Elm Fork are based on values provided by the 2016 Region C RWP.

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.

The connected supply numbers from the eastern subsystem lakes of Tawakoni and Fork assume that all the supply can be delivered to Dallas. This assumes that the 144" eastside transmission line currently included in Dallas' Capital Improvement Plan will be constructed by 2030.

5.3 Dallas System Reservoir Yields and Supplies

This section provides the current (year 2020) and future (year 2070) firm yields of Dallas' supply reservoirs and Dallas' portion of those yields available as a supply to meet demands. Firm yields and supplies are presented in this section for the 1950's drought and the 1908 drought. In addition, calculated losses of supplies projected to occur between 2020 and 2070 as a result of projected increases in temperature and sedimentation are presented and discussed.

5.3.1 Dallas Portion of Reservoir Yields

Since Dallas operates most of its reservoirs with other entities or partners, a review of Dallas' agreements with these entities was performed by Dallas' water rights attorney (Webb & Webb) to estimate the percentage of firm yield that Dallas has rights to from each of its water supply reservoirs. These percentages are summarized in Table 5-4.

Table 5-4. Dallas' Portion of Reservoir Yields

Units: as noted in table

Reservoir	Dallas Percentage of Yield
Lake Grapevine [a]	41%
Lake Ray Roberts	74%
Lake Lewisville	95.2%
Lake Ray Hubbard	100%
Lake Tawakoni	80%
Lake Fork	70%
Lake Palestine [b]	53.73%

[a] Dallas' contract for Lake Grapevine water does not stipulate a yield share percentage. The 41% value was provided by Dallas staff based on lake operations considering the reservoir accounting plan that stipulates diversion limits for each of the three entities that have rights in the reservoir.
[b] Dallas' contract for Lake Palestine water stipulates that its share is 53.73% of the original dependable yield cannot exceed 102.07 MGD (114,337 acft/yr).

5.3.2 Current (Year 2020) and Future (2070) Connected Reservoir Supplies

Current (2020 conditions) firm yields and connected supplies available to Dallas for both the eastern and western subsystems are shown in Table 5-5. The subsystem yield totals summarized in Table 5-5 reveal that the critical drought for the western subsystem is the 1950's drought and for the eastern subsystem is the 1908 drought. When total system supplies are compared, the 1908 drought has 8.0 MGD (9,000 acft/yr) or 1.6 percent less total system supply in comparison to the 1950's drought.

Future (2070 conditions) firm yields and supplies available for both Dallas' eastern and western subsystems are shown in Table 5-6. The reservoir subsystem yields summarized in Table 5-6 reveal that for 2070 conditions, the critical drought for the western subsystem is the 1950's drought and for the eastern subsystem is the 1908 drought. When total system supplies are compared, the 1950's drought has 4.0 MGD (4,500 acft/yr) or 0.9 percent less total system supply in comparison to the 1908 drought.

As shown in Table 5-5 and Table 5-6, there is a significant difference in individual reservoir firm yields between the 1950's and 1908 droughts. However, there is not a significant difference in the sum of the future connected supplies. As a result, the 2014 LRWSP utilizes the 1950's drought supply numbers for comparison with demands to determine future needs. The use of the 1950's drought supplies allows for consistency with previous long range water supply plans and the RWP.

Table 5-5. Current (Year 2020) Reservoir Firm Yields and Supply Available to Dallas

Units: MGD

Reservoir	Reservoir Firm Yield		Supply Available to Dallas	
	1950's Drought	1908 Drought	1950's Drought	1908 Drought
Lake Grapevine	31.1	35.9	12.8	14.7
Elm Fork System [a]	188	221	162	189
Additional Elm Fork Return Flows	13.3	13.3	13.3	13.3
Western Subsystem	**232.4**	**270.2**	**188.1**	**217**
Lake Ray Hubbard	50.0	61.7	50.0	61.7
Lake Tawakoni	196	160	157	128
Lake Fork	145	118	107	87.6
Eastern Subsystem [b]	**391**	**339.7**	**314**	**277.3**
Total System	**623.4**	**609.9**	**502.1**	**494.3**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions made from the Elm Fork at Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought is assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD. The estimated yield of the run-of-river diversion for the 1908 drought was assumed to be the 1908-1913 average annual tributary flow of 17.4 MGD.

[b] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

Table 5-6. Future (Year 2070) Reservoir Firm Yields and Supply Available to Dallas

Units: MGD

Reservoir	Reservoir Firm Yield		Supply Available to Dallas	
	1950's Drought	1908 Drought	1950's Drought	1908 Drought
Lake Grapevine	24.9	30.0	10.2	12.3
Elm Fork System [a]	151	186	130	160
Additional Elm Fork Return Flows	50.3	50.3	50.3	50.3
Western Subsystem	**226.2**	**266.3**	**190.5**[b]	**222.6** [b]
Lake Ray Hubbard	45.4	57.7	45.4	57.7
Lake Tawakoni	168	142	135	113
Lake Fork	122	98.2	90.4	72.7
Eastern Subsystem [c]	**335.4**	**297.9**	**270.8**	**243.4**
Total System	**561.6**	**564.2**	**461.3**	**466**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions made from the Elm Fork at Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought was assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD. The estimated yield of the run-of-river diversion for the 1908 drought was assumed to be the 1908-1913 average annual tributary flow of 17.4 MGD.

[b] Western subsystem supplies increase between 2020 and 2070 as a result of increases in Elm Fork return flows.

[c] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

Table 5-7 provides a summary showing the worst-case drought yield and supply available to Dallas for 2020 and 2070 conditions considering the drought starting in 1908 and the 1950's drought. The 1950's drought is the drought of record for the western subsystem supplies and Lake Ray Hubbard. The 1908 drought is the worst drought for Lakes Tawakoni and Fork. For 2020 the supply available to Dallas considering the 1950's drought is 502.1 MGD compared to 453.7 MGD when considering the worst drought for each supply source. This is a potential reduction in the supply available to Dallas of 9.6 percent. The combined worst drought supply available to Dallas for 2020 reservoir conditions is 48.4 MGD less that the 1950's drought and 40.6 MGD less than the drought starting in 1908. For 2070 the supply available to Dallas considering the 1950's drought is 461.3 MGD compared to 421.6 MGD when considering the worst drought for each supply source. This is a potential reduction in the supply available to Dallas of 8.6 percent. The combined worst drought supply available to Dallas for 2070 reservoir conditions is 39.7 MGD less that the 1950's drought and 44.7 MGD less than the drought starting in 1908. The potential for recurrence of the worst drought simultaneously at all of Dallas' supply reservoirs suggest that some amount of supply buffer should be considered to deal with this contingency.

Table 5-7. Reservoir Firm Yields and Supply Available to Dallas Considering the Worst-Drought

Table units: MGD

Reservoir	2020 Reservoir Conditions		2070 Reservoir Conditions	
	Yield / Dallas Supply	Drought Period	Yield / Dallas Supply	Drought Period
Lake Grapevine	31.1 / 12.8	1950's	24.9 / 10.2	1950's
Elm Fork System [a]	188 / 162	1950's	151 / 130	1950's
Additional Elm Fork Return Flows	13.3 / 13.3	-	50.3 / 50.3	-
Western Subsystem	**232.4 / 188.1**	**1950's**	**226.2 [b] / 190.5**	**1950's**
Lake Ray Hubbard	50 / 50	1950's	45.4 / 45.4	1950's
Lake Tawakoni	160 / 128	1908	142 / 113	1908
Lake Fork	118 / 87.6	1908	98.2 / 72.7	1908
Eastern Subsystem [c]	**328 / 265.6**	**both**	**285.6 / 231.1**	**both**
Total System	**560.4 / 453.7**	**both**	**511.8 / 421.6**	**both**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions made from the Elm Fork at Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought was assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD. The estimated yield of the run-of-river diversion for the 1908 drought was assumed to be the 1908-1913 average annual tributary flow of 17.4 MGD.

[b] Western subsystem supplies increase between 2020 and 2070 as a result of increases in Elm Fork return flows.

[c] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

A supply buffer (specific application of this concept for the City of Dallas is explained in Section 6) is an amount of total supply available greater than the projected demands being planned for in the future. Many terms are used to describe this concept including safe yield, safety factor, resilient supplies, etc. Supply buffer is developed by connecting supplies in advance of the demands of the system. Supply buffer not only provides safety and system resiliency for unexpected events such as a new more severe drought, but it can also be used to provide operational flexibility and supply redundancy within the water supply system.

5.3.3 Projected Impacts to Supplies from Predicted Future Temperature Increases

All of the previous yields discussed include the effects of predicted increases in surface air temperatures in northeast Texas as estimated by global climate models (GCMs), as discussed in Appendix I. These GCMs predict an average high temperature increase from historical average high temperatures of 2°F by the 2020 decade and 7°F by 2070 for the northeast Texas region. The period used to determine historical average high temperature for this analysis was 1961 – 2000. Assuming this predicted increase in temperature occurs; it will lead to an increase in reservoir evaporation and consequently reduce reservoir yields. To quantify what portion of the above reductions in reservoir yields are a result of predicted temperature increases, additional reservoir simulations were performed to isolate the impacts of these predicted increases.

Table 5-8 provides a summary of projected reductions to Dallas' supplies based on predicted temperature increases from climate models. Supply reductions were calculated by simulating the reservoirs with 2070 sediment conditions and both 2020 temperature conditions (2°F increase from historical conditions) and predicted 2070 temperature increases (7°F increase from historical conditions). Table 5-8 lists Dallas' portion of the reservoir yields for the 2020 and 2070 climate scenarios under firm yield operations for the 1950's drought. The purpose of this analysis and table is to show the projected impact to Dallas' yields of anticipated climate change, which is different than the information presented in Table 5-7. Included in the table is the volume decrease and percent decrease of supplies for each reservoir and the total reduction in supply. This summary shows that Dallas' total system supply would be reduced by 60.7 MGD (about 68,000 acft/yr) if average high temperatures increase by 5°F between 2020 and 2070. This represents an overall reduction in supply of 12.9 percent.

Table 5-8. Projected Reductions in Supplies from Predicted Increases in Air Temperature (2070 Sediment Conditions) and Recurrence of the 1950's drought

Table units: MGD

Reservoir	Supply Available to Dallas [a]		
	2020 Adjusted Evaporation (+2°F)	2070 Adjusted Evaporation (+7°F)	Decrease (% Decrease)
Lake Grapevine	12.3	10.2	2.1 (17%)
Elm Fork System	156	130	26 (16.7%)
Lake Ray Hubbard	48.4	45.4	3.0 (6%)
Lake Tawakoni	151	135	16.0 (10.6%)
Lake Fork	104	90.4	13.6 (13.1%)
Total	**471.7**	**411**	**60.7 (12.9%)**

[a] Supply available to Dallas is based on the 1950's drought and 2070 sediment conditions.

5.3.4 Projected Impacts to Supplies from Future Sedimentation

All of the previously listed reservoir yields and supplies include the effects of reservoir sedimentation. Figure 5-2 provides a comparison of 2020 and 2070 conservation pool capacities for Dallas' reservoirs and shows the percentage of capacity lost to sediment accumulation during this 50 year timeframe.

Model simulations were performed to isolate the impacts from sedimentation on Dallas' reservoirs. These simulations did not change anticipated future climate conditions, only the sediment conditions (2020 and 2070) were modified. The results are summarized in Table 5-9 and show that the effects of sedimentation on supply are unique to each reservoir. Overall, sedimentation is anticipated to reduce the combined conservation capacity of Dallas reservoirs by 310,626 acft or 9 percent between 2020 and 2070. However, the combined reduction in reservoir firm yield is 17.1 MGD (19,170 acft/yr) or only 3.5 percent.

Figure 5-2. Comparison of 2020 and 2070 Reservoir Conservation Pool Capacities based on Estimated Sediment Conditions

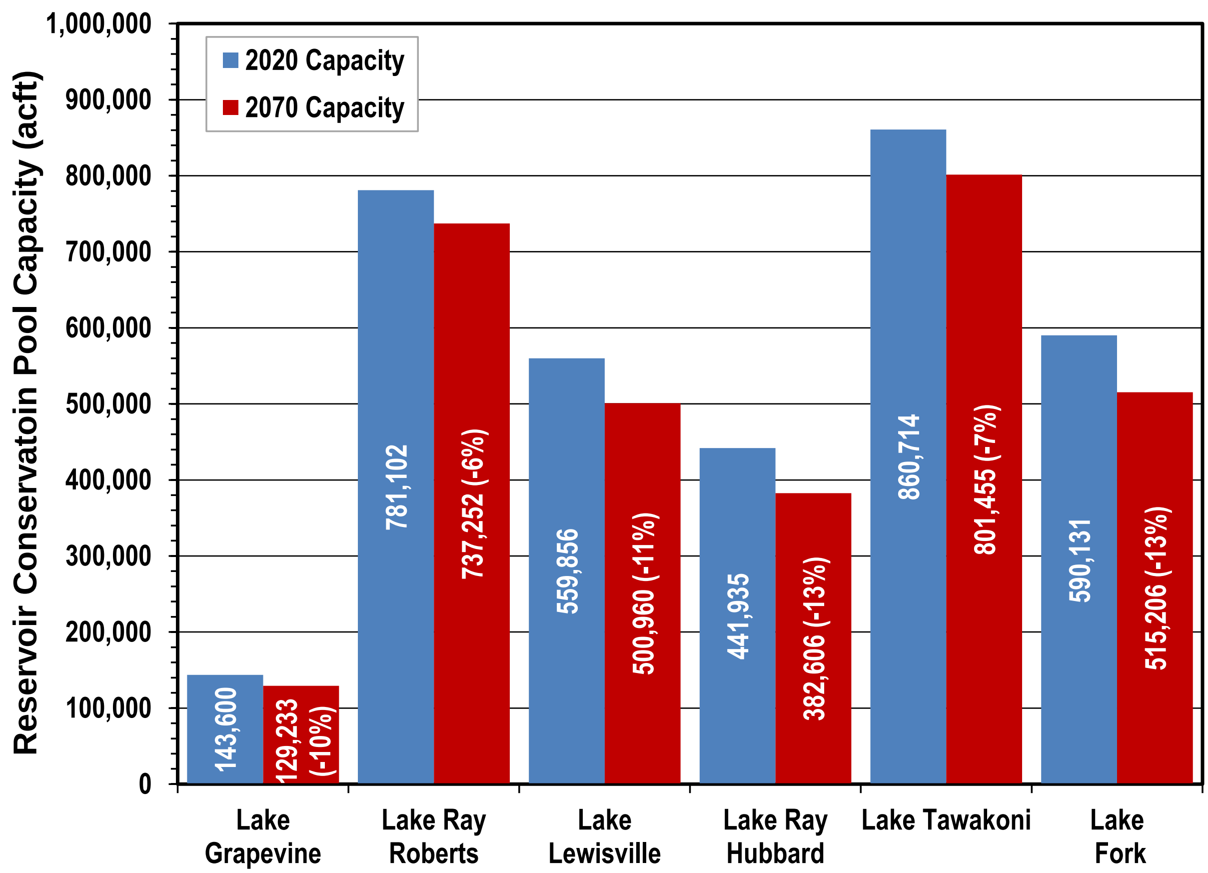


Table 5-9. Projected Reductions in Supply from Future Sedimentation

Table units: MGD unless otherwise noted

Reservoir	Supply Available to Dallas (MGD)[a]			Conservation Pool Reduction (acft) (% Decrease)
	2020 Sediment Conditions	2070 Sediment Conditions	Decrease (% Decrease)	
Lake Grapevine	12.8	12.3	0.5 (3.9%)	14,367 (10%)
Elm Fork System	162	156	6.0 (3.7%)	102,746 (7.7%)
Lake Ray Hubbard	50	48.4	1.6 (3.2%)	59,329 (13.4%)
Lake Tawakoni	157	151	6.0 (3.8%)	59,259 (6.9%)
Lake Fork	107	104	3.0 (2.8%)	74,925 (12.7%)
Total	**488.8**	**471.7**	**17.1 (3.5%)**	**310,626 (9.2%)**

[a] Supply available to Dallas is based on the 1950's drought and assuming only a 2°F increase in temperature. Does not include estimated return flows since return flows are not impacted by sedimentation in Dallas' reservoirs. These assumptions show the impact of sedimentation on Dallas' supply reservoirs.

5.3.5 Lake Palestine

Table 5-10 provides the firm yields and supply available to Dallas from Lake Palestine for current and future conditions for the 1950's, 1908 drought, and more recent 2006 drought. As per Dallas' contract with UNRMWA, Dallas' share of the reservoir is limited to 53.73 percent of the original dependable yield or 102 MGD of supply from Lake Palestine. The 1908 drought is the critical drought of record for Lake Palestine, resulting in a yield of 131 MGD. Figure 5-3 shows a storage trace for Lake Palestine under 2020 conditions with the 1908 drought firm yield demand of 150 MGD. The storage trace shows that the 1908 drought and more recent 2006 drought were both more severe than the 1950's drought. Table 5-10 compares the 1950's, 1908, and 2006 firm yields and supplies available to Dallas for both 2020 and 2070 conditions.

Table 5-10. Comparison of Lake Palestine Firm Yields and Supply Available to Dallas for Three Droughts based on 2020 Conditions

Table units: MGD

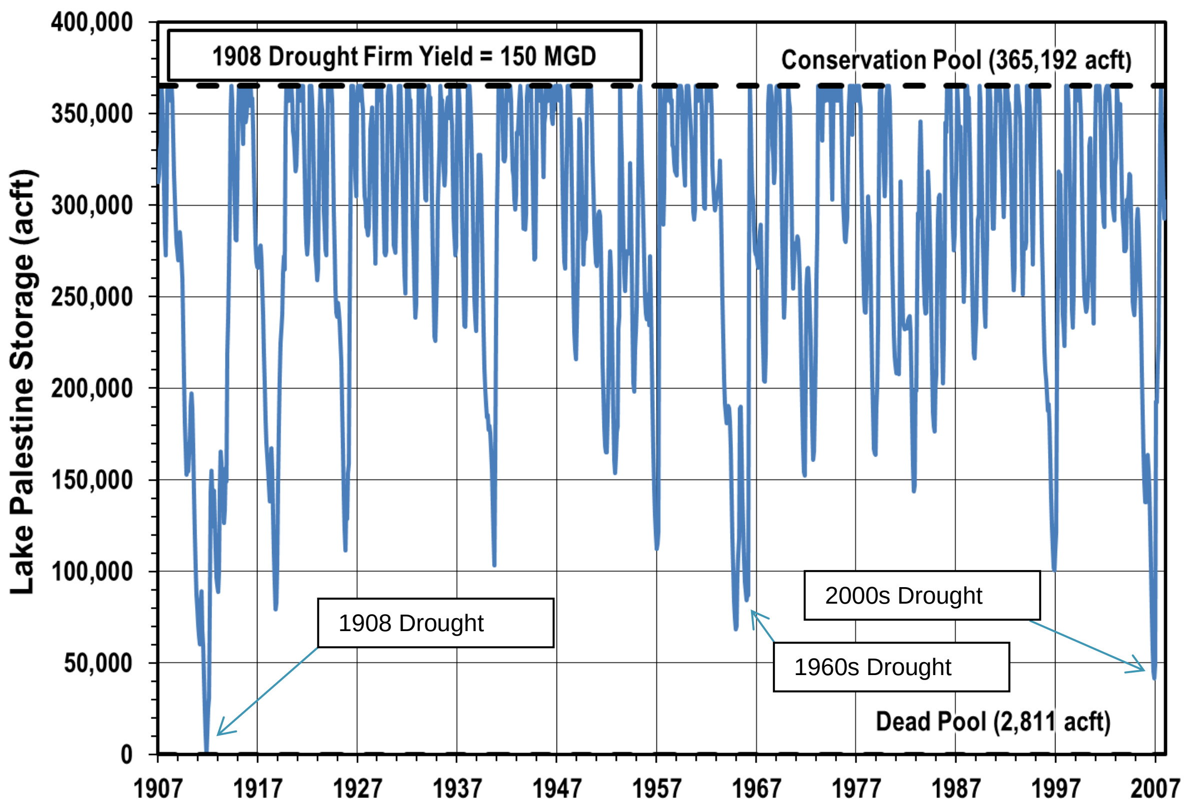
Current/Future Conditions	Reservoir Firm Yield			Supply Available to Dallas [a]		
	1950's Drought	1908 Drought	2006 Drought	1950's Drought	1908 Drought	2006 Drought
Current (Year 2020)	175	150	164	102	102	102
Future (Year 2070)	160	131	142	102	102	102

[a] Dallas' contract with UNRMWA stipulates that Dallas' supply from Lake Palestine is limited to 53.73% of the original yield of the reservoir up to a maximum of 102 MGD.

The effect of sedimentation on Lake Palestine's supply to Dallas was calculated for the 1950's drought. It is estimated that Lake Palestine will lose 54,380 acft or 15 percent of its conservation pool storage as a result of sedimentation. This loss of storage results in a loss of 3.9 MGD of firm yield for the 1950's drought but does not result in any loss of supply to Dallas as Dallas' portion of the yield does not drop below 102 MGD.

The effect of projected temperature increases on Lake Palestine's supply to Dallas was also calculated for the 1950's drought. The predicted 5°F increase in temperature from 2020 to 2070 is calculated to have an 11.0 MGD reduction on Lake Palestine's firm yield. Similar to the impacts from sedimentation, the impacts from the projected temperature increase does not reduce Dallas' portion of the firm yield below 102 MGD and therefore does not have an impact on Dallas supply from Lake Palestine.

Figure 5-3. Lake Palestine Storage Trace (1908 Drought Firm Yield and 2020 Conditions)



5.4 Summary

Table 5-11 provides a summary of Dallas' authorized diversions and contracts, current and future supplies available to Dallas, and supply losses resulting from both evaporation due to potential increases in temperature and sedimentation for Dallas' reservoirs through the 50 year period from 2020 to 2070 for the 1950's drought. The 2020 supply shown in Table 5-11 assumes a 2°F increase in high temperatures from historical averages and 2020 sediment conditions. The 2070 supply shown assumes a 7°F increase in high temperatures from historical averages and 2070 sediment conditions. It is estimated that Dallas will lose 77.8 MGD (87,100 acft/yr) or 13.0 percent of its reservoir supply from 2020 to 2070 from these two factors. Of this total supply loss, 60.7 MGD (68,000 acft/yr) or 78 percent is predicted to be a result of increases in evaporation and 17.1 MGD (19,100 acft/yr) or 22 percent is predicted to occur due to sedimentation. The 2070 firm yield available to Dallas of 563.3 MGD (632,200 acft/yr) is 1,056 MGD (1,183,700 acft/yr) or 65 percent less than the sum of the authorized (non-reuse) diversions and contracts of 1,620 MGD (1,815,900 acft/yr).

Table 5-11. Summary of Dallas' Authorized Diversions and Contracts and Future (Year 2070) Firm Yields Available to Dallas

Table units: MGD

Reservoir	Dallas' Authorized Diversions and Contracts (MGD)	2020 Firm Yield Available to Dallas (MGD)	Projected Losses from Temperature Increases (MGD)	Projected Losses from Sedimentation (MGD)	2070 Firm Yield Available to Dallas (MGD)
Lake Grapevine	75.9	12.8	2.1	0.5	10.2
Elm Fork System [a]	1,074.0	162.0	26.0	6.0	130.0
Additional Elm Fork Return Flows	220.7 [d]	13.3	0.0	0.0	50.3
Lake Palestine [e]	102.0	102.0	0.0	0.0	102.0
Western Subsystem	**1,472.6**	**290.1**	**28.1**	**6.5**	**292.5**
Lake Ray Hubbard	80.1	50.0	3.0	1.6	45.4
Lake Tawakoni	170.0	157.0	16.0	6.0	135.0
Lake Fork	117.0	107.0 [c]	13.6	3.0	90.4
Eastern Subsystem [b]	**367.1**	**314.0**	**32.6**	**10.6**	**270.8**
Total System	**1,839.7**	**604.1**	**60.7**	**17.1**	**563.3**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions made at Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought was assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD

[b] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

[c] The 107 MGD is the interbasin transfer amount available to Dallas from Lake Fork for use in the Trinity Basin. The authorization for Dallas is for a total of 117.7 MGD (131,860 acft/yr) with 107 MGD (120,000 acft/yr for use in the Trinity Basin.

[d] Total reuse diversion authorization contained in Dallas Permit 12468.

[e] Lake Palestine is not currently connected to the Dallas system, but is expected to be through the recommended IPL strategy. Note there are no evaporation or sediment losses shown because even though the reservoir experiences these losses, Dallas' portion remains whole.

Figure 5-4 illustrates Dallas' connected supplies and projected losses from 2020 to 2070. A portion of the losses will be offset by the projected increase in additional Elm Fork return flows available to Dallas. These return flows are projected to increase from 13.3 MGD in 2020 to 50.3 MGD in 2070. Table 5-12 provides a summary of Dallas' connected and unconnected (Lake Palestine) supplies by decade from 2020 to 2070.

Figure 5-5 compares Dallas' total current (2020 conditions) firm yield connected supply for the 2014 LRWSP to the 2005 Dallas LRWSP and the 2011 Region C RWP estimates of total supplies. A comparison of the 1950's drought firm yield supplies as calculated for the 2014 LRWSP shows a 6.7 percent decrease compared to the 2005 Dallas LRWSP and a 4.9 percent decrease compared to the 2011 Region C RWP. A comparison of the 2014 LRWSP 1908 firm yield drought supplies to the previous studies shows an 8.2 percent decrease compared to the 2005 Dallas LRWSP and a 6.4 percent decrease compared to the 2011 Region C RWP. A majority of the decrease in supplies between the 2014 Dallas LRWSP and the previous studies can be attributed to the projected supply losses resulting from evaporation due to potential increases in temperature included in the 2014 Dallas LRWSP.

Figure 5-6 compares Dallas' total 2070 firm yield connected supply as calculated for the 2014 LRWSP to the 2005 Dallas LRWSP and the 2011 Region C RWP estimates for 2060 conditions. A comparison of the 1950's drought firm yield supplies as calculated for the 2014 LRWSP shows a 16 percent decrease compared to the 2005 Dallas LRWSP and the 2011 Region C RWP. A comparison of the 2014 LRWSP 1908 firm yield drought supplies shows a 15 percent decrease compared to the 2005 Dallas LRWSP and the 2011 Region C RWP. Similar to the current supply comparisons, a majority of the decrease in supplies between the 2014 Dallas LRWSP and the previous studies for future conditions can be attributed to the projected supply losses resulting from evaporation due to potential increases in temperature included in the 2014 LRWSP.

Figure 5-4. Dallas Connected Supply considering Losses from Projected Temperature Increases and Sedimentation

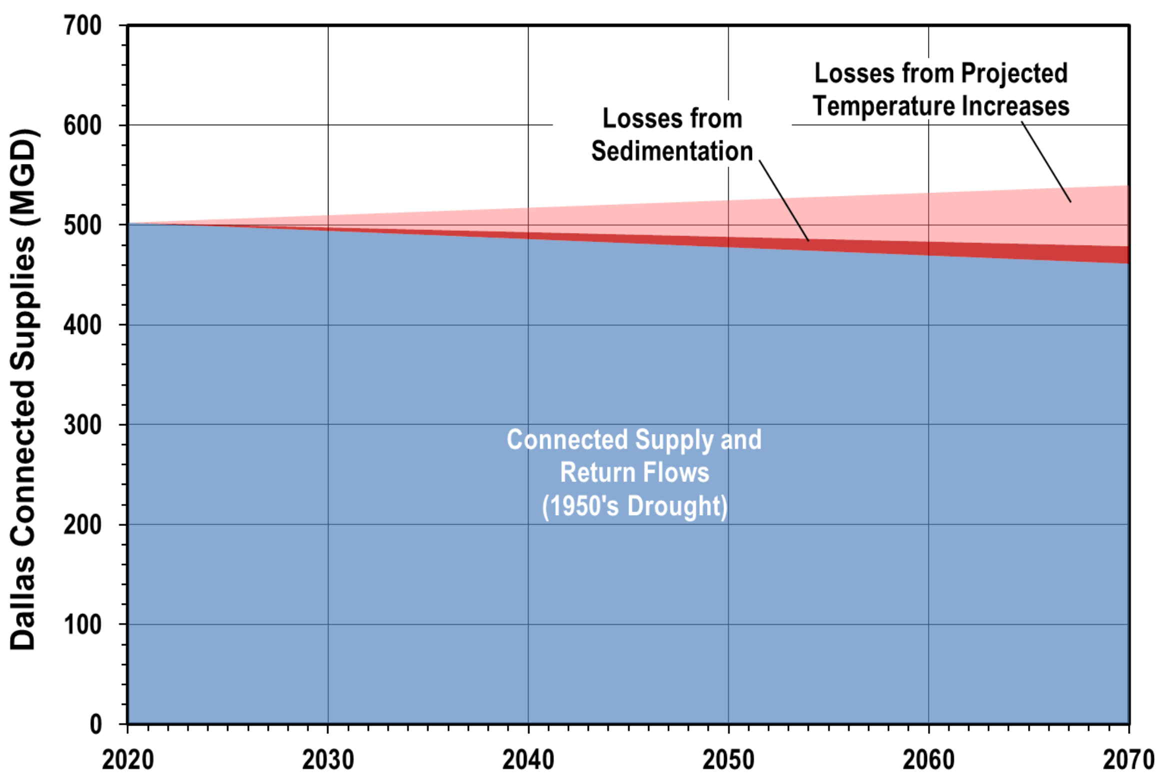


Table 5-12. Summary of Dallas' Connected and Unconnected Supply by Decade

Table units: MGD

Reservoir	2020	2030	2040	2050	2060	2070
Lake Grapevine	12.8	12.3	11.8	11.2	10.7	10.2
Elm Fork System [a]	162	155	149	143	136	130
Additional Elm Fork Return Flows	13.3	16.4	20.8	29.2	41.8	50.3
Lake Ray Hubbard	50.0	49.1	48.1	47.3	46.3	45.4
Lake Tawakoni [b]	157	152	148	144	139	135
Lake Fork [b,c]	107	104	101	97.3	93.8	90.4
Total Connected Supply	**502.1**	**488.8**	**478.7**	**472.0**	**467.6**	**461.3**
Lake Palestine [d]	102	102	102	102	102	102
Total Connected and Unconnected Supply	**604.1**	**590.8**	**580.7**	**574.0**	**569.6**	**563.3**

[a] Yields include Lake Ray Roberts, Lake Lewisville and run-of-river diversions above Frasier Dam. The estimated yield of the run-of-river diversion for the 1950's drought was assumed to be the 1951-1956 average annual tributary flow of 14.5 MGD

[b] Assumes connection of 144-in eastside transmission pipeline to deliver full amount of Dallas' portion of Lake Fork and Lake Tawakoni supplies.

[c] The 107 MGD is the interbasin transfer amount available to Dallas from Lake Fork for use in the Trinity Basin. The authorization for Dallas is for a total of 117.7 MGD (131,860 acft/yr) with 107 MGD (120,000 acft/yr for use in the Trinity Basin.

[d] Dallas' contract with UNRMWA stipulates that Dallas' supply from Lake Palestine is limited to 53.73% of the yield up to a maximum of 102 MGD.

Figure 5-5. Comparison of Current (2020 Conditions) Total Connected Supplies

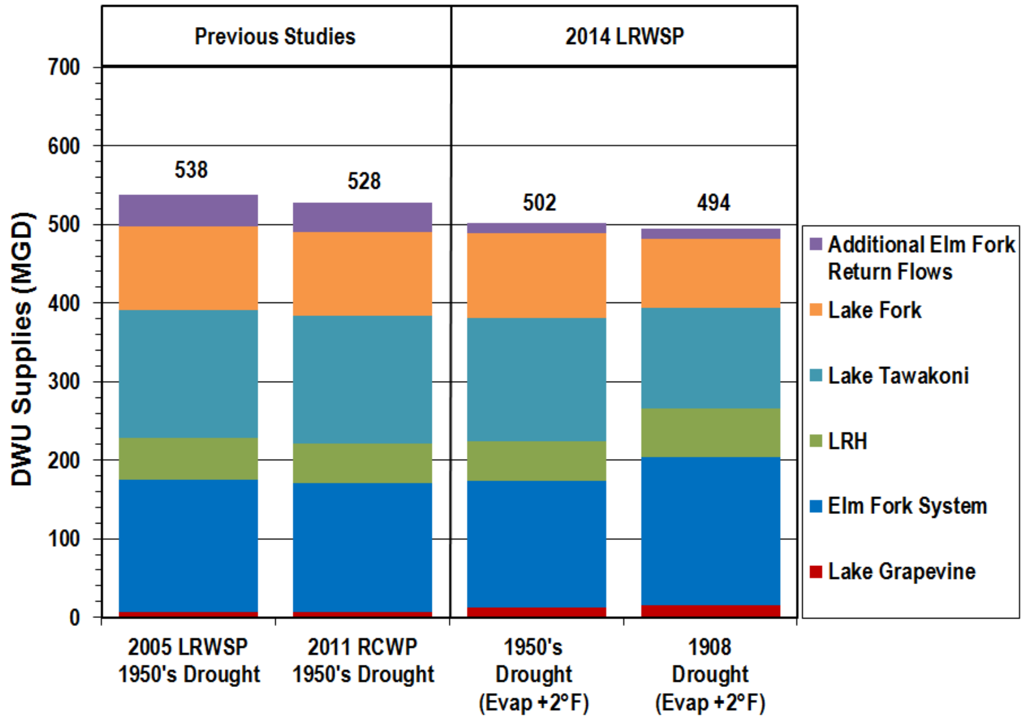
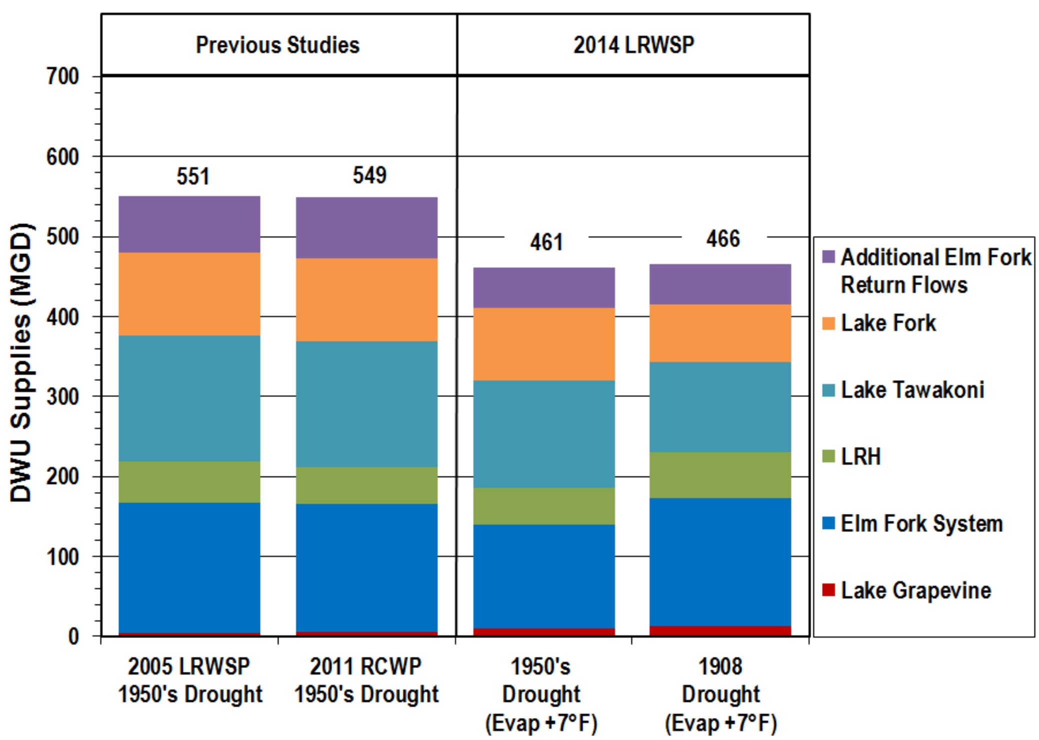


Figure 5-6. Comparison of Future Total Connected Supplies (2060 Conditions for Previous Studies and 2070 Conditions for 2014 LRWSP)



6 Water Supply Needs and Recommended Plan

6.1 Introduction

> - **Benjamin Franklin**
>
> *By failing to prepare, you are preparing to fail.*

This section presents Dallas' future water supply needs resulting from growth in population and water demands and considers predicted reductions in existing supplies. The first part of this section summarizes future water needs for Dallas considering the findings of the previous sections. The latter part of this section provides the recommended plan for Dallas to meet these future needs through 2070 and beyond.

6.2 Water Supply Needs

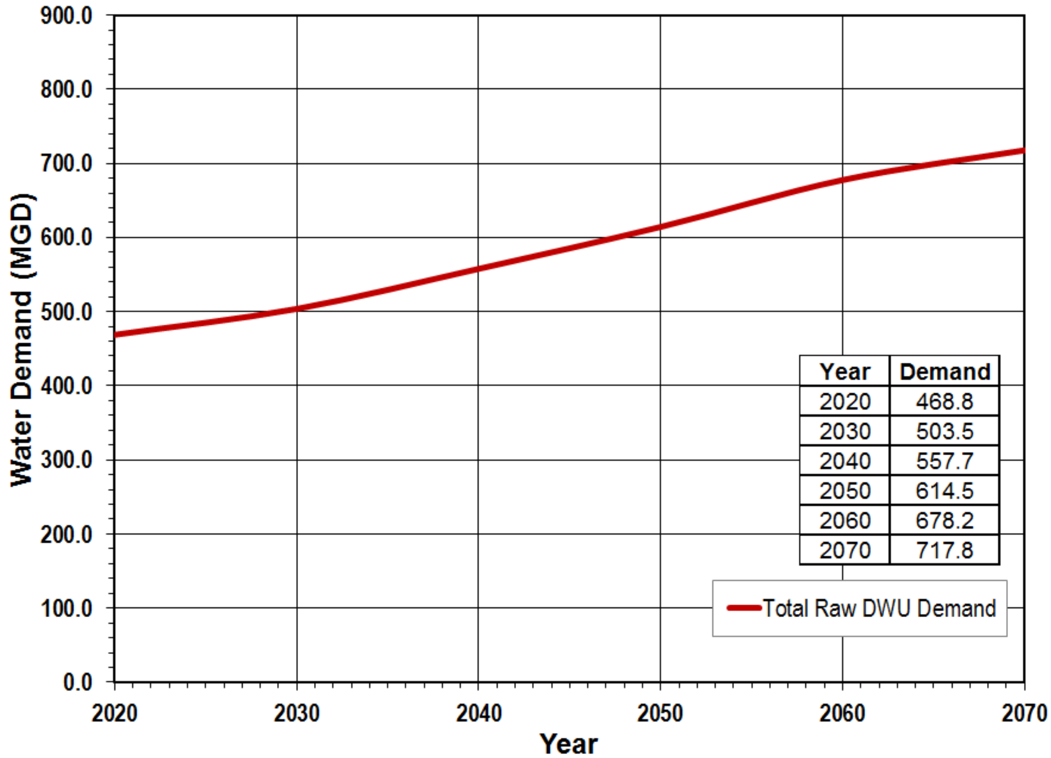
Future water supply need is the difference between future demand and available supply. When demand is greater than the available supply, the difference is commonly called a deficit. When the available supply is greater than demand, the difference is commonly referred to as a buffer. Dallas' future demands are projected to increase as a result of population growth, while Dallas' 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 supplies at some point in the future. The plan is to incrementally add additional supply to the Dallas system to overcome the deficit and provide a buffer.

Figure 6-1 shows the estimated total raw water demand for Dallas through 2070, as shown in the section 4 tables and in Table 6-1. This demand is the total water needed at Dallas' treatment plants plus the demand of its customer cities that purchase untreated water from Dallas. These demands represent drought or dry year demands consistent with the RWP process.

Figure 6-2 shows the total existing connected supply available from Dallas' reservoirs through 2070 as shown in the Section 5 tables and Table 6-1. These supplies include future reductions considering reservoir sedimentation and increased evaporation as a result of predicted future temperature increases. These supplies are based on firm yield estimates of these reservoirs and Dallas' portion of these reservoirs as constrained by contract or agreement. These supplies include predicted growth in return flows that are available for diversion by Dallas as estimated in the 2016 Region C RWP and discussed in Section 5.3.

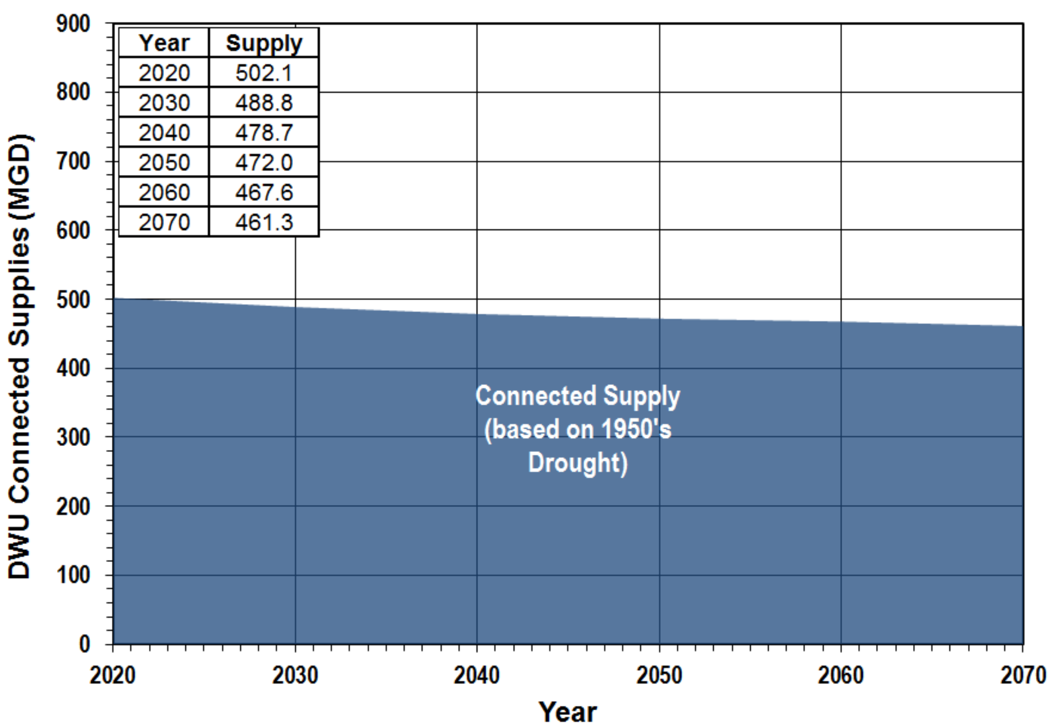
Figure 6-3 combines the data from the previous figures and shows when demand is expected to overtake supply resulting in a supply deficit. This figure shows that in 2020 Dallas will have a total supply system buffer of 33 MGD and by 2070 will have a supply deficit of 256 MGD. Dallas' supply deficit begins to occur before the 2030 decade (about 2027) given the predicted growth in demand and the rate of declining supplies.

Figure 6-1. Total Raw Water Demand for DWU System



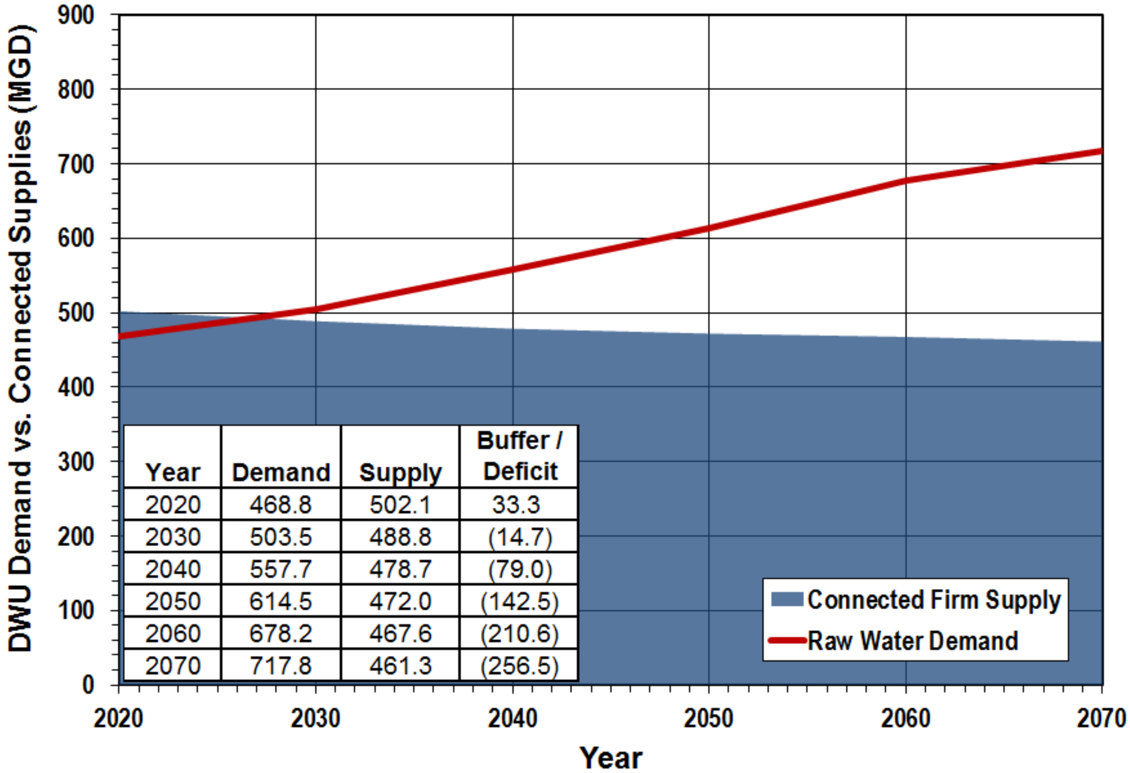
Source: 2016 Region C RWP (as of September 12, 2014)

Figure 6-2. Total Connected Raw Water Supply for DWU System



Note: Dallas' portion of the firm yields of the connected supply reservoirs based on the 1950's drought.

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



Year	Demand	Supply	Buffer / Deficit
2020	468.8	502.1	33.3
2030	503.5	488.8	(14.7)
2040	557.7	478.7	(79.0)
2050	614.5	472.0	(142.5)
2060	678.2	467.6	(210.6)
2070	717.8	461.3	(256.5)

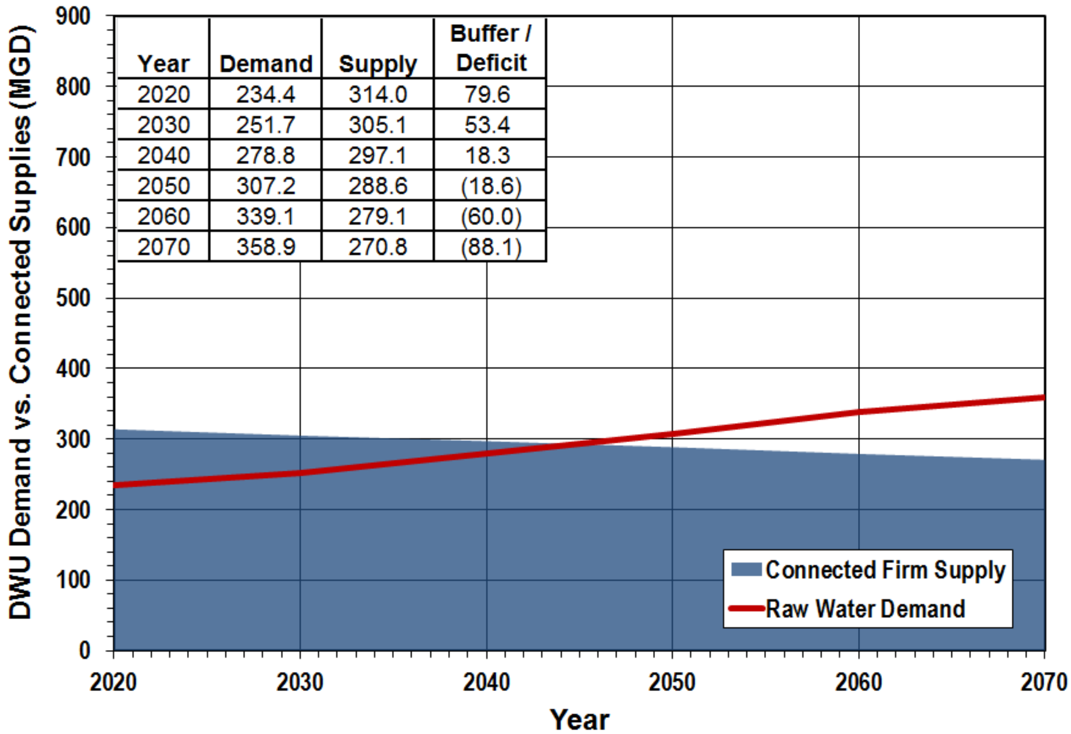
Note: Figure shows that Dallas will have a supply deficit starting in about 2027.

For the purposes of planning and throughout this report, the Dallas water supply system is described as consisting of two subsystems referred to hereafter as the eastern subsystem and the western subsystem. Each subsystem is supplied by its own set of supply reservoirs. Analysis of Dallas' water treatment and distribution system performed for the 2014 LRWSP shows that demand between these two subsystems vary, but can generally be split 50 percent to the east and 50 percent to the west. This is the assumption that was adopted for planning purposes. However the supplies available from the reservoirs that supply each subsystem are not split evenly and consequently, neither are the resulting needs. In practice, the distribution system is not isolated based on treatment plant or specific supply.

6.2.1 Eastern Subsystem Needs

The eastern subsystem is supplied from three reservoirs including Lake Ray Hubbard, Lake Tawakoni, and Lake Fork with these reservoirs all delivering water to the Eastside WTP. Figure 6-4 compares the connected supply for the eastern subsystem with the demands for the east subsystem based on the 50/50 percent demand split between east and west. In 2020 the eastern subsystem is estimated to have a buffer of 80 MGD and by 2070 is estimated to have a deficit of 88 MGD. As shown on Figure 6-4 a supply deficit for the eastern subsystem is estimated to occur about 2045.

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

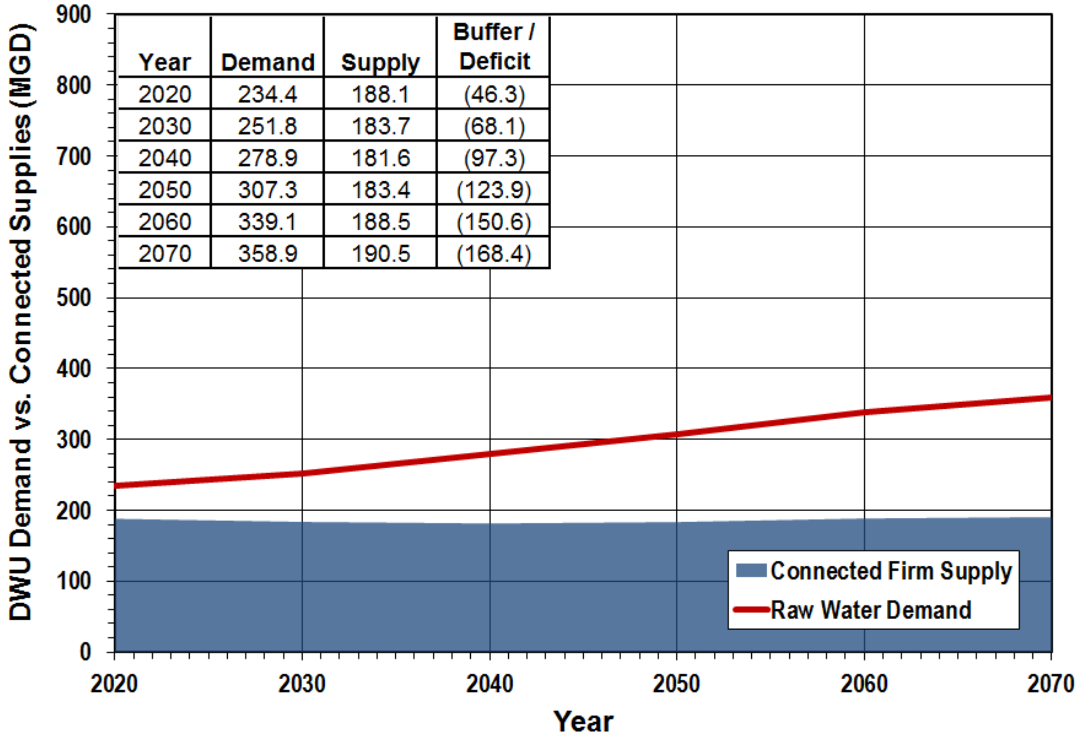


Year	Demand	Supply	Buffer / Deficit
2020	234.4	314.0	79.6
2030	251.7	305.1	53.4
2040	278.8	297.1	18.3
2050	307.2	288.6	(18.6)
2060	339.1	279.1	(60.0)
2070	358.9	270.8	(88.1)

6.2.2 Western Subsystem Needs

The western subsystem is supplied from Lake Lewisville, Lake Ray Roberts, and the Elm Fork run of river rights (commonly referred to as the Elm Fork System), and Lake Grapevine with all water being delivered to the Elm Fork and Bachman WTPs. Figure 6-5 compares demands and supplies for the western subsystem using the 50/50 percent demand split between east and west. Note: This is different than the 50/50 percent WTP demand split discussed in Section 8 regarding treatment plant capacity. Dallas treats water for Irving that is supplied by Irving, not Dallas, and therefore not part of Dallas' raw water demand. In 2020 the western subsystem is estimated to have a deficit of 47 MGD and by 2070 a deficit of 168 MGD. Unlike DWU's eastern supplies, DWU's western supplies are not predicted to decrease through time due to the increase in return flows estimated to be available to DWU. These estimated return flows increase at essentially the same rate as the reduction in supplies expected from the combination of reservoir sedimentation and increased evaporation due to warmer temperature.

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



6.2.3 Water Supply Needs – Summary of Findings

The DWU system as a whole is estimated to need additional supplies connected prior to 2027. However, when considering DWU's two subsystems separately, the need for additional supply occurs prior to 2020 for the western subsystem. DWU has the operational flexibility within its distribution system to shift supplies between the two subsystems to as much as a 40/60 percent split.[1] DWU can use this operational flexibility to temporarily shift up to about 60 percent of the demand to the eastern subsystem. This flexibility allows Dallas to cover some of the early deficits shown for the western subsystem in Figure 6-5.

The following list summarizes key findings from the 2014 LRWSP regarding Dallas' future water supply needs. This list highlights major findings that were considered during the process of selecting recommended strategies for Dallas to implement to meet the needs of the system for the next 50 years and beyond.

- The Dallas water supply system is comprised of two subsystems.
  - The Dallas eastern subsystem includes Lake Ray Hubbard, Lake Tawakoni and Lake Fork all of which deliver to the Eastside WTP.

[1] Integrated Pipeline Project Conceptual Design Operations Study. Tarrant Regional Water District and City of Dallas. April 20, 2012.

  - The Dallas western subsystem includes Lake Ray Roberts, Lake Lewisville, Lake Grapevine, and run of the river rights all of which deliver to the Bachman and Elm Fork Water Treatment Plants.
  - Dallas demands between the two subsystems are generally split 50/50 percent.
  - Dallas has operational flexibility to shift demands between the two subsystems up to a 60/40 percent split which allows for near-term western subsystem deficits to be met from eastern subsystem supplies and treatment facilities. This split can be even greater with distribution system improvements.
- Dallas needs additional connected supply by about 2027 in order to maintain an overall system supply buffer. However, Dallas needs additional supply on the western subsystem sooner than the eastern subsystem.

Considering the above findings, Table 6-1 presents DWU demand, supply and need information for both its western and eastern subsystems and for the total system.

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

Table units: MGD

Supplies and Demands	2020	2030	2040	2050	2060	2070
Western Subsystem						
Lake Grapevine Supply	12.8	12.3	11.8	11.2	10.7	10.2
Elm Fork System Supply	162	155	149	143	136	130
Elm Fork Return Flows [a]	13.3	16.4	20.8	29.2	41.8	50.3
Western Subsystem Supply Total	188.1	183.7	181.6	183.4	188.5	190.5
50% Demand	234.4	251.8	278.9	307.3	339.1	358.9
Buffer / Deficit	(46.3)	(68.1)	(97.3)	(123.9)	(150.6)	(168.4)
Eastern Subsystem						
Lake Ray Hubbard Supply	50.0	49.1	48.1	47.3	46.3	45.4
Lake Tawakoni Supply	157	152	148	144	139	135
Lake Fork Supply	107	104	101	97.3	93.8	90.4
Eastern Subsystem Supply Total [b]	314	305.1	297.1	288.6	279.1	270.8
50% Demand	234.4	251.7	278.8	307.2	339.1	358.9
Buffer / Deficit	79.6	53.4	18.3	(18.6)	(60.0)	(88.1)
Total System						
Total Supply	**502.1**	**488.8**	**478.7**	**472**	**467.6**	**461.3**
Total Demand	**468.8**	**503.5**	**557.7**	**614.5**	**678.2**	**717.8**
Buffer / Deficit	**33.3**	**(14.7)**	**(79)**	**(142.5)**	**(210.6)**	**(256.5)**

[a] Includes increases in return flows available to Dallas in the Elm Fork System above the amount of return flows included in Dallas' 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 Dallas CIP for construction by 2030.

6.3 Dallas Water Supply Plan

One of the main goals of the 2014 LRWSP includes identifying, evaluating, and selecting water management strategies that could be implemented by Dallas to meet future water supply needs. As seen in Table 6-1, Dallas needs 242 MGD of additional supply by 2070 to overcome the projected supply deficit from the combination of population growth and existing supply reductions. The 2014 LRWSP utilized a rigorous process to identify and evaluate strategies that could potentially meet Dallas' needs. These strategies were evaluated with respect to cost, supply quantity, potential environmental concerns, and overall feasibility. The goal of the process was to select strategies that provided the greatest benefits to Dallas while minimizing costs and environmental impacts.

The highest ranking strategies selected as a result of this process are referred to as preferred strategies. These are strategies that the analyses ranked high with respect to cost, supply quantity, potential environmental concerns and overall feasibility. These preferred strategies have been separated into two groups, recommended and alternative. The recommended strategies are the most favorable of the preferred strategies and are the strategies that Dallas intends to implement to meet its needs. The remaining strategies are referred to as alternative strategies and these strategies have been identified to replace the recommended strategies in the event one or more of the recommended strategies were to become infeasible. In the RWP process, alternative strategies can be used to replace recommended strategies if implementation plans for recommended strategies change over time.

6.3.1 Preferred Strategies

The 2014 LRWSP strategy evaluation and ranking process resulted in a list of 14 preferred strategies. These 14 preferred strategies rose to the top of the rankings after over 300 strategies were considered as identified from previous plans and studies as well as new strategies evaluated as part of the 2014 LRWSP. These preferred strategies served as the pool of strategies from which the recommended and alternative strategies were then selected. Table 6-2 provides a summary of the preferred strategies including the projected supply quantity and estimated unit cost associated with each.

6.3.2 Recommended Strategies

Recommended strategies are strategies that Dallas will actively pursue and implement in the future to meet the needs identified in the 2014 LRWSP. These recommended strategies are the focus of the implementation plan presented in this report. The recommended water supply strategies are listed in Table 6-3. Figure 6-6 provides a breakdown of the projected supply from the recommended strategies by type. Supply from reuse accounts for the greatest piece with 36 percent of the total projected supply for all of the recommended strategies.

Figure 6-7 shows the location of these recommended strategies in comparison to Dallas' existing water supply sources and transmission system. Note that part of the Lake Palestine Integrated Pipeline project (IPL) is shared with TRWD and the TRWD only components are not shown on Figure 6-7. The IPL project blends Dallas and TRWD supplies in the joint pipeline before being delivering the supplies to Dallas and TRWD. The two most significant recommended supply strategies for Dallas with respect to the quantity of supply being developed include the connection of two existing supplies including Lake Palestine and indirect reuse associated with the Main Stem Pump Station and the Main Stem Balancing Reservoir. These supplies are relatively close to Dallas and thus generally have a lower capital cost than more distant supplies. A brief description of each recommended strategy is presented in the following subsections. Section 7 provides a detailed evaluation of the recommended and alternative strategies and the process by which these strategies were selected.

Table 6-2. Preferred Strategies – Summary of Projected Supply and Unit Cost

Strategy Name	Projected Supply (MGD)	Unit Cost ($/1,000 gal)
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 [a]	-	$2.31
IPL Part 2 – Connection to Bachman WTP [a]	-	$0.49
Direct Reuse – Alternative 1	2.23	$2.24
Carrizo Wilcox Groundwater (Alternative 2)	26.7	$1.80
Neches Run-of-River	42.2	$1.88
Lake Columbia	50.0	$1.78
Sabine – Conjunctive Use (OCR and groundwater)	93.0	$2.27
Red River OCR	102	$2.27
Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5) [b]	102	$2.28
Toledo Bend Reservoir	179	$3.14
Lake Texoma Desalination	130	$3.64

[a] Note that there are two components to the IPL strategy and that both are required to be implemented for Dallas to receive the additional supply of 102 MGD. The unit cost shown here include Dallas' respective portion of each project necessary to deliver water to the Dallas system.

[b] At the time of the Dallas City Council adoption of the recommended strategies the draft Sulphur Basin Wide Study identified reservoir elevations to determine yield and cost. Additional studies will be necessary to identify specific project elevations / configurations.

Table 6-3. Recommended Strategies for Dallas

Recommended Strategies	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Additional Conservation	46.4	$51.7 [a]	$0.38
Indirect Reuse Implementation - Main Stem Pump Station – NTMWD Swap Agreement	31.1	$25.9 [b]	$0.25
Indirect Reuse Implementation - Main Stem Balancing Reservoir	102	$675	$1.74
Connect Lake Palestine	102 [c]	-	-
IPL Part 1 – Connection to Lake Palestine [c]	-	$939	$2.31
IPL Part 2 – Connection to Bachman WTP [c]	-	$244	$0.49
Neches Run-of-River	42.2	$227	$1.88
Lake Columbia	50.0	$289	$1.78
Totals	**373.7**	**$2,451.6**	**$1.24 [d]**

[a] Equivalent total project cost based on net present value analysis for the 50-year planning horizon. See Section 7.6.2 for detail.

[b] Represents Dallas' portion of the total project cost, see Section 7.3 for more details.

[c] The IPL project requires both of the projects to provide 102 MGD of supply to the Dallas system.

[d] This value is calculated by amortizing the total project cost at 5.5% for 30 years and dividing by projected supply by 1,000 gallons.

Figure 6-6. Comparison of Recommended Strategies by Type

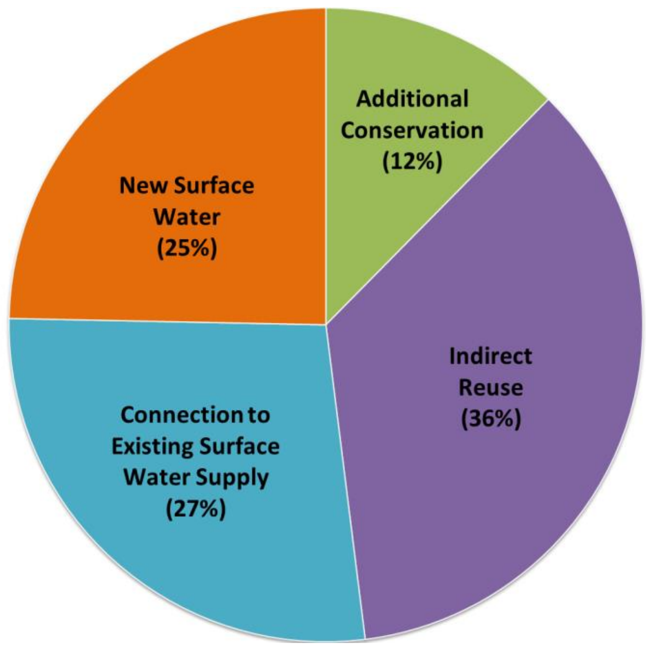
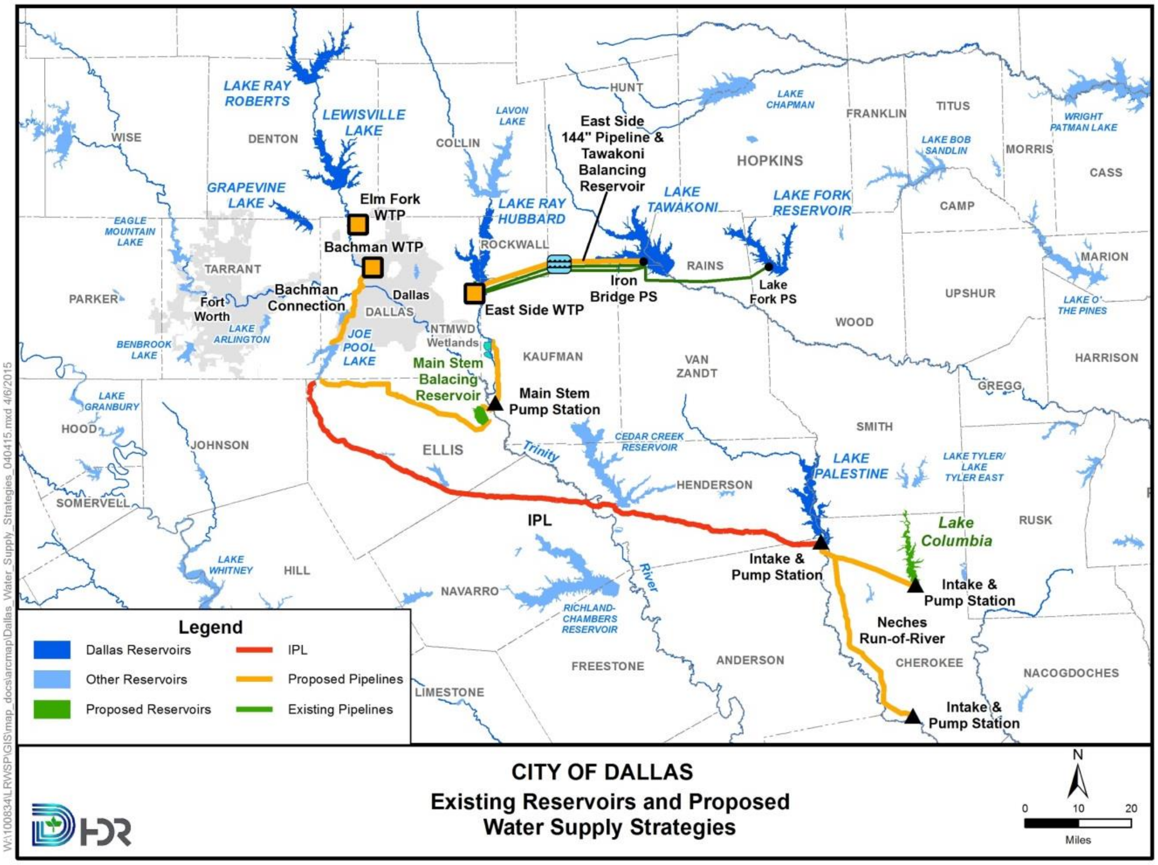


Figure 6-7. Dallas Water Supply System showing Recommended Strategies *



* Note: IPL is a joint project between Dallas and TRWD. The IPL project shown on this map does not include segments that are 100% TRWD capacity.

Additional Conservation

Additional conservation is one of the most efficient strategies to meet Dallas' future needs. This strategy encompasses many different aspects, but consists of many actions by DWU and its customers to reduce water use as well as actions to reduce or eliminate losses throughout the treatment and distribution system. Additional conservation is currently being implemented by DWU as evidenced by Dallas' recent update to its water conservation plan and the planned update of the water conservation work plan. Dallas' water conservation efforts have been extremely successful with more than 17 percent reduction in per capita water use from about 250 GPCD in 2000 to about 207 GPCD in 2011. Additional conservation efforts will benefit both the eastern and western supply systems. Dallas' additional conservation efforts are expected to reduce Dallas' GPCD rate by an additional 25 GPCD (more than a 13 percent reduction) for an overall additional savings of 46.4 MGD throughout the 50-year planning period. Costs for this strategy were obtained from the Dallas 2010 Strategic Water Conservation Plan.

Indirect Reuse Implementation

Indirect reuse is the process of reusing treated effluent for water supply purposes in such a way that an environmental barrier or treatment process exists between the discharge and the reintroduction of this water into a water treatment plant. Dallas has identified two such indirect reuse projects as part of the 2014 LRWSP.

Main Stem Pump Station In 2008 Dallas entered into an agreement with the North Texas Municipal Water District (NTMWD) to swap a portion of Dallas' 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 31 MGD. The swap allows Dallas to impound NTWMD 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 would be constructed at a location below the confluence of the East Fork and the main stem of the Trinity River and would divert a portion of Dallas' return flows from the Central and Southside WWTPs to NTMWD's East Fork wetlands project.

Main Stem Balancing Reservoir Dallas currently has a water rights 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 acre feet) 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 off channel storage reservoir (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 MGD by 2070.

Connect Lake Palestine

Lake Palestine is owned and operated by the Upper Neches River Municipal Water Authority (UNRMWA). Dallas contracted with the UNRMWA for 53.73 percent of the yield of Lake Palestine up to a maximum of 102 MGD, whichever is less. There are two related strategies that are necessary to connect this supply to Dallas' western subsystem.

IPL – Part 1 Connection to Lake Palestine 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 Dallas, and additionally bring Richland Chambers and Cedar Creek Reservoir supplies to TRWD. Dallas has a 150 MGD capacity share in this pipeline. TRWD is currently moving forward with the design and construction of the joint segment of this pipeline. Dallas' portion of the project includes an intake in Lake Palestine, transmission pipeline to connect to the IPL, and a share of the cost of the IPL.

IPL – Part 2 Connection to Bachman WTP There is a segment of the IPL known as the Bachman turnout. This is the location where Dallas' portion of the supplies from the IPL will be split off and brought into the Dallas system. The current plan for delivery of this water is to bring water to the Bachman WTP through a pipeline from the turnout near the Joe Pool Lake area. The pipeline options require the construction of large diameter pipelines through densely developed areas as well as a crossing of the Trinity River levees. However, no booster stations are required to move water from the IPL to Bachman as the residual head from the IPL is sufficient. Other options were evaluated to look at using stream channels and lakes to reduce the amount of pipe to be constructed. A recommendation of the 2014 LRWSP is for Dallas to evaluate these potential cost saving strategies, in partnership with other entities, in a follow-on study to the 2014 LRWSP that will better define Dallas' future plans for the delivery of the IPL into the Dallas system including the possibility of expanding Dallas' west side treatment capacity by 150 MGD and associated distribution system improvements. This follow-on study would consider other critical components such as water quality and blending issues associated with storing IPL and other water from the Neches River, the Main Stem Balancing Reservoir, and Lake Columbia (as discussed below) in Joe Pool Lake.

Neches Run-of-River

Dallas has been working with the Upper Neches River Municipal Water Authority (UNRMWA) on the Neches River Water Supply Project Feasibility Study to look at the development of additional supplies in the Neches River Basin. Several alternatives were identified in this study and were included in the strategy evaluations for the 2014 LRWSP. The highest ranking Neches option is a run-of-river diversion option 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 Dallas through the IPL pump station and pipeline. This strategy is estimated to supply about 42 MGD.

Lake Columbia

The Angelina Neches River Authority (ANRA) has been actively pursing 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 this project is estimated by ANRA to be approximately 50 MGD. 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 Dallas through the IPL pump station and pipeline.

6.3.3 Alternative Strategies

The 2014 LRWSP includes a group of alternative strategies that were also identified from the list of preferred strategies. Alternative strategies are strategies that could be developed in the event one or more of the recommended strategies encountered an implementation obstacle that could not be overcome. It is recommended that Dallas continue to evaluate these strategies, along with the implementation of the recommended strategies, to be in a position to move an alternative strategy to a recommended strategy if the need arises. The alternative strategies are shown in Table 6-4 and include projected supply, total project cost, and unit cost. Unit cost is derived by taking the amortized total project cost and adding annual operations and maintenance costs to derive an annual cost which is then divided by the volume of supply provided by the project.

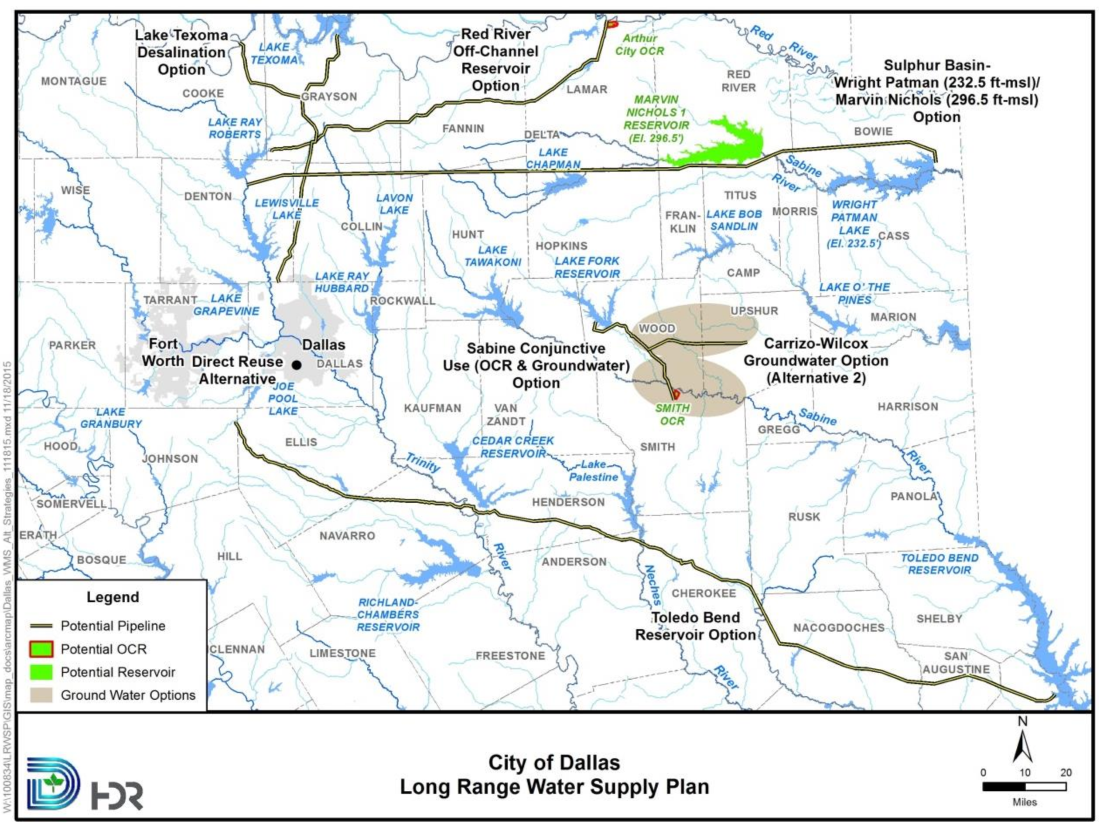
Section 7 provides a detailed evaluation of the alternative strategies including how costs were derived and the process by which these strategies were selected. Figure 6-8 shows the locations of the alternative strategies. Note that these strategies are typically located further from Dallas than the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

Table 6-4. Alternative Strategies for Dallas

Alternative Strategy	Projected Supply (MGD)	Total Project Cost (Million Dollars)	Unit Cost ($/1,000 gal)
Direct Reuse – Alternative 1	2.23	$27.4	$2.43
Carrizo Wilcox Groundwater (Alternative 2)	26.7	$161	$1.80
Sabine – Conjunctive Use (OCR and groundwater)	93.0	$796	$2.27
Red River OCR	102	$853	$2.27
Sulphur Basin Project - Wright Patman (232.5) / Marvin Nichols (296.5) [1]	102	$1,003	$2.28
Toledo Bend Reservoir	179	$2,290	$3.14
Lake Texoma Desalination	130	$1,382	$3.54

[1] Specific water surface elevations for Wright Patman and Marvin Nichols were selected from the draft "Sulphur River Basin Wide Feasibility Study Final Cost Rollup Report" for costing purposes only. Additional studies will be necessary to finalize water surface elevations and project configurations.

Figure 6-8. Alternative Strategies



6.3.4 Approval of Dallas City Council and Coordination with Region C

A preliminary list of recommended and alternative strategies was presented to the Dallas City Council for consideration and questions at its September 15, 2014, Dallas City Council Briefing Meeting (September Briefing). At the October 8, 2014, Dallas City Council Agenda Meeting, the recommended and alternative strategies presented at the September Briefing were approved by the City Council. This approval included the authorization for DWU staff to include the recommended and alternative strategies in the 2014 LRWSP and to submit these recommended and alternative strategies to the Region C RWPG for inclusion in the 2016 Region C RWP. A copy of the adopted council resolution is provided in Appendix J.

During the development of the 2014 LRWSP, the 2016 Region C RWP process has been underway. To the extent possible Dallas has relied on the planning data contained in the Region C RWP in order to be consistent with the Regional and State plans. Dallas and the Region C RWPG consultants have had an open communication throughout the plan development with the Director of DWU sitting on the Region C RWPG. Dallas will provide the Region C RWPG data from the evaluation of the recommended and alternative strategies for inclusion in the Regional and State Water Plans. 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 has requested that the Region C RWP reference and include the 2014 LRWSP as part of the 2016 Region C RWP.

6.4 Implementation Timeline

Once the recommended strategies were selected, it was necessary to determine the implementation schedule for these projects. Table 6-5 summarizes the needs for Dallas by decade and shows the recommended decade of implementation for each strategy. Note that strategies are not selected to just meet the needs of Dallas, zeroing out the deficit. The goal is to provide a supply buffer as shown on the table to help ensure that supplies are sufficient in the event a project is delayed or a worse drought were to occur. This information is presented graphically in Figure 6-9. Figure 6-10 provides a breakdown of all projected supplies in 2070 by type. Projected supplies from recommended strategies will make up 45 percent of the total supply by 2070 with reuse accounting for 16 percent of the total supply.

6.4.1 East versus West Implementation

As discussed in Section 6.2, implementation of projects should be considered on not only a total system perspective but also considering east versus west subsystem needs. Table 6-6 presents the recommended strategy implementation from a subsystem perspective. This information is presented graphically in Figure 6-11 for the east subsystem and Figure 6-12 for the west subsystem.

Table 6-5. Recommended Strategy Implementation Timeline

Table units: MGD

Demand / Supply / Strategy	2020	2030	2040	2050	2060	2070
Current System						
Projected Raw Water Demand	468.8	503.5	557.7	614.5	678.8	717.8
Available Connected Supply	502.1	488.8	478.7	472	467.6	461.3
Buffer / Deficit	33.3	(14.7)	(79)	(142.5)	(210.6)	(256.5)
Recommended Water Management Strategies						
Additional Conservation	10.9	24.6	36.3	42.2	44.9	46.4
Indirect Reuse Implementation						
Main Stem Pump Station – NTMWD Swap Agreement	23.1	27.5	31.1	31.1	31.1	31.1
Main Stem Balancing Reservoir	-	-	-	75	90	102
Connect Lake Palestine	-	102	102	102	102	102
IPL Part 1 – Connection to Lake Palestine IPL Part 2 – Connection to Bachman WTP	-	-	-	-	-	-
Neches Run-of-River	-	-	-	-	42.2	42.2
Lake Columbia	-	-	-	-	-	50
Total Future System						
Supply from Recommended Strategies	**34**	**154.1**	**169.4**	**250.3**	**310.2**	**373.7**
Total Supplies	**536.1**	**642.9**	**648.1**	**722.3**	**777.8**	**835**
Buffer / Deficit	**67.3**	**139.4**	**90.4**	**107.8**	**99**	**117.2**
Percent Buffer of Total Supplies	**12.6%**	**21.7%**	**13.9%**	**14.9%**	**12.7%**	**14.0%**

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

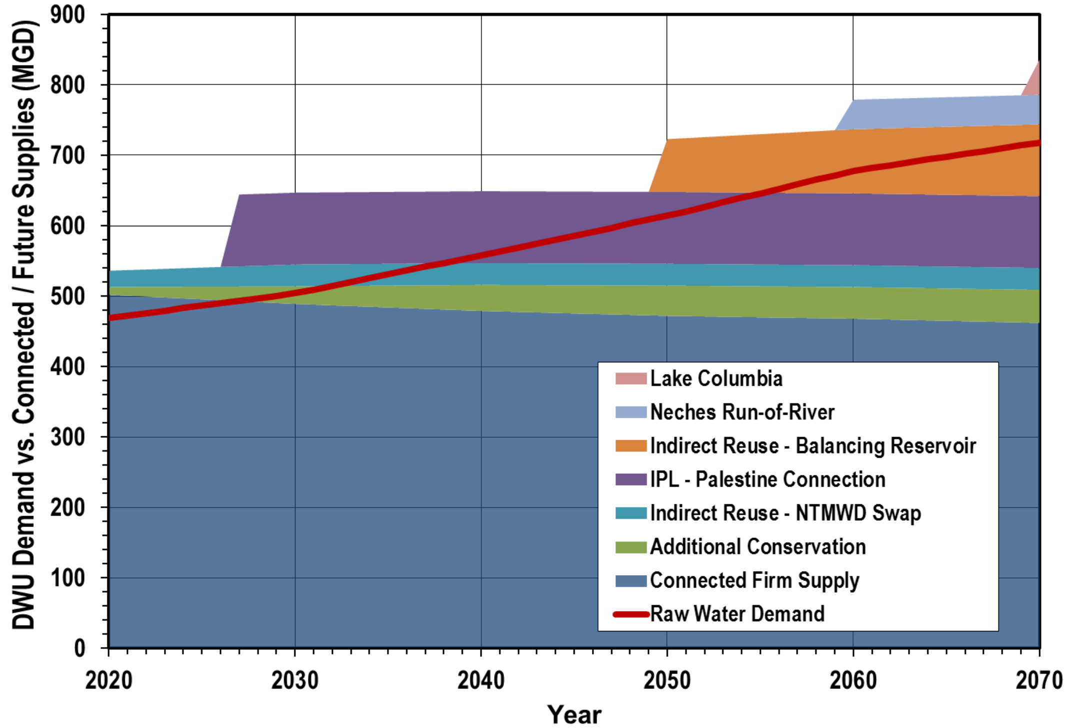
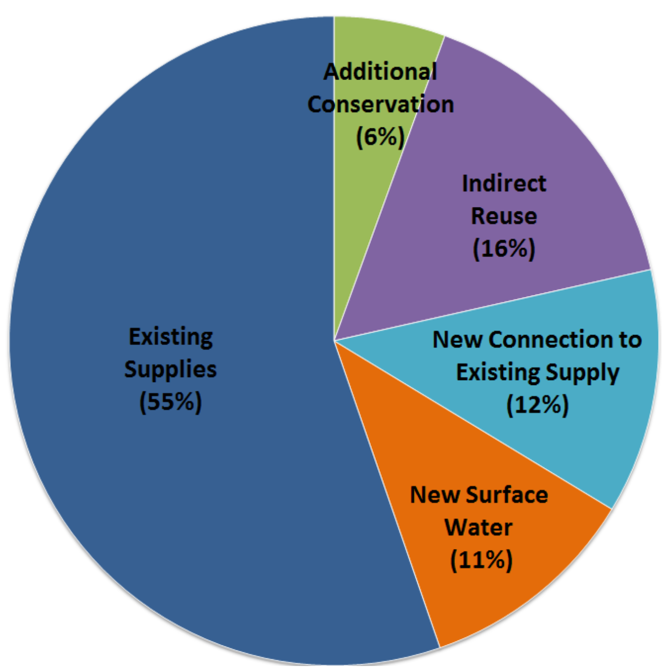


Figure 6-10. Comparison of 2070 Connected Supply and Recommended Strategies by Type



Additional conservation is split between the two subsystems with an approximate 50/50 percent split just like the demands are split. In the 2020 decade, the eastern subsystem will have to make up some of the deficit on the western subsystem and the 50/50 percent split will be restored when the IPL is implemented. In the later decades of 2060 and 2070 this trend will shift again and the western subsystem is anticipated to make up for small deficits on the eastern subsystem, unless the Neches and/or Lake Columbia strategies are subsequently modified to deliver water to the east subsystem.

Table 6-6. Recommended Strategy Implementation Timeline by Subsystem

Table units: MGD

Demand / Supply / Strategy	2020	2030	2040	2050	2060	2070
Current Eastern Subsystem						
Projected Raw Water Demand	234.4	251.7	278.8	307.2	339.1	358.9
Existing Connected Supplies	314	305.1	297.1	288.6	279.1	270.8
Buffer / Deficit	79.6	53.4	18.3	(18.6)	(60.0)	(88.1)
Recommended Water Management Strategies for Eastern Subsystem						
Additional Conservation	5.4	12.3	18.2	21.1	22.5	23.2
Main Stem Pump Station – NTMWD Swap Agreement	23.1	27.5	31.1	31.1	31.1	31.1
Supply from Recommended Strategies	**28.5**	**39.8**	**49.3**	**52.2**	**53.6**	**54.3**
Total Supplies	**342.5**	**344.9**	**346.4**	**340.8**	**332.7**	**325.1**
Buffer / Deficit (East Subsystem)	**108.1**	**93.2**	**67.6**	**33.6**	**(6.4)**	**(33.8)**
Current Western Subsystem						
Projected Raw Water Demand	234.4	251.8	278.9	307.3	339.1	358.9
Existing Connected Supplies	188.1	183.7	181.6	183.4	188.5	190.5
Buffer / Deficit	(46.3)	(68.1)	(97.3)	(123.9)	(150.6)	(168.4)
Recommended Water Management Strategies for Western Subsystem						
Additional Conservation	5.5	12.3	18.1	21.1	22.4	23.2
Main Stem Balancing Reservoir	-	-	-	75	90	102
Connect Lake Palestine	-	-	-	-	-	-
IPL Part 1 – Connection to Lake Palestine IPL Part 2 – Connection to Bachman WTP	-	102	102	102	102	102
Neches Run-of-River	-	-	-	-	42.2	42.2
Lake Columbia	-	-	-	-	-	50
Supply from Recommended Strategies	**5.5**	**114.3**	**120.1**	**198.1**	**256.6**	**319.4**
Total Supplies	**193.6**	**298**	**301.7**	**381.5**	**445.1**	**509.9**
Buffer / Deficit (West Subsystem)	**(40.8)**	**46.2**	**22.8**	**74.2**	**106**	**151**

Figure 6-11. Recommended Strategy Implementation Timeline for Eastern Subsystem (comparing Demands and Supplies)

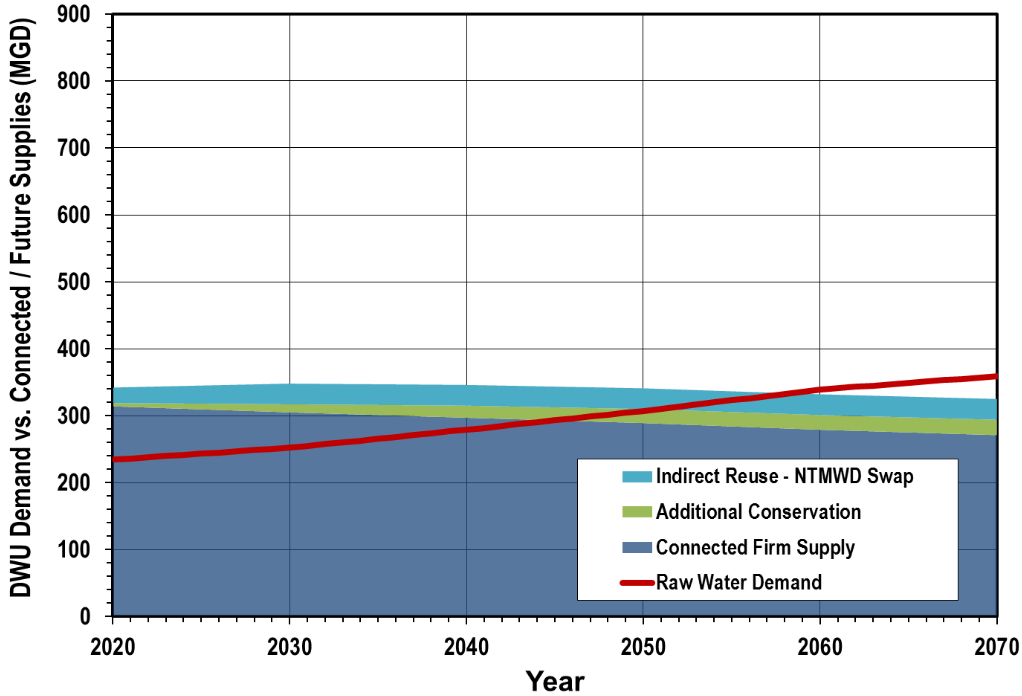
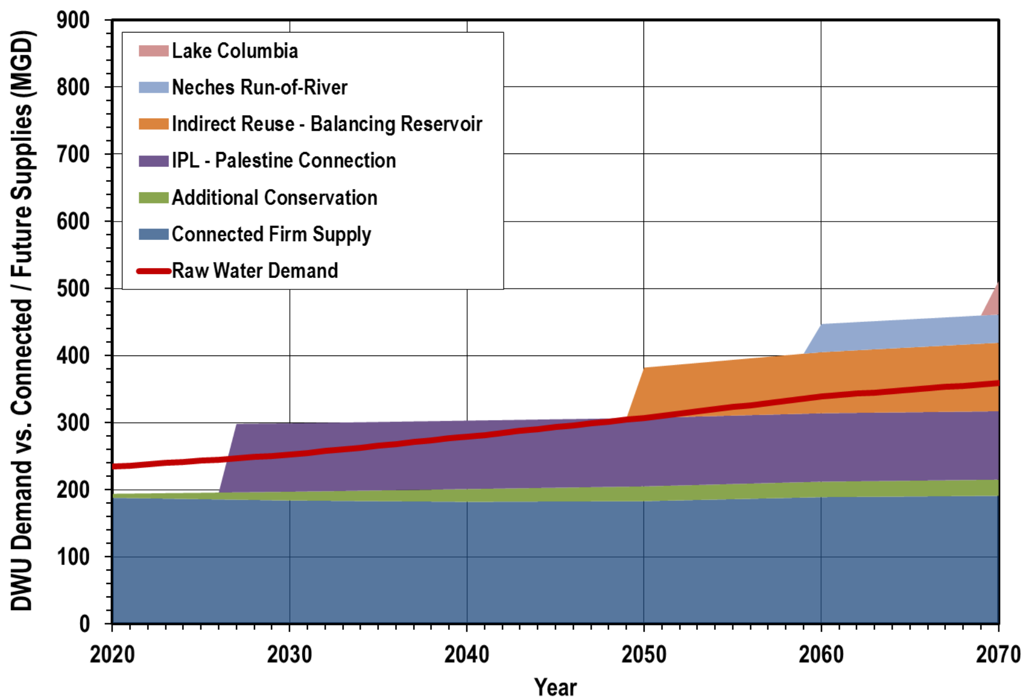


Figure 6-12. Recommended Strategy Implementation Timeline for Western Subsystem (comparing Demands and Supplies)



6.5 Implementation Risks and Next Steps

There are many potential obstacles that can be encountered along the path of project development and implementation. Today's regulatory and permitting environment is the most challenging in history and project implementation requires steadfast dedication and solid planning to overcome these challenges. For the 2014 LRWSP, a list of implementation steps have been identified for each strategy to help Dallas move forward with securing these supplies and overcome the risks associated with project development. These implementation steps are first presented for each of the individual recommended strategies and then for the alternative strategies as a group.

In addition to the risks of development for specific strategies there are general risks that need to be considered as the 2014 LRWSP is implemented. These include:

- Changes in State and Federal regulations and permitting requirements that impact project implementation.
- Changes in long-term climate patterns that could reduce the water available to some projects from droughts that are more severe or have longer durations than previously evaluated droughts of record.
- Competition for water wherein another entity develops a project that utilizes all or a portion of the same source as a Dallas strategy.
- Creation of critical habitat designation, wildlife refuges, etc. within the footprint of a proposed project.
- Demands increasing at a rate faster than projected resulting in potentially accelerating the implementation schedule.

6.5.1 Additional Conservation

Dallas continues to actively improve its water conservation efforts with the recent adoption of an update to its water conservation plan and the planned update of its strategic water conservation plan. These documents guide and document how Dallas plans, achieves, and monitors savings from conservation. The biggest risk to achieving the supply savings associated with additional conservation is the ability to continue to modify consumer behavior. Achieving additional conservation savings becomes more challenging as these savings are realized. Generally, easier programs are implemented first with more advanced programs that are more costly or require a greater level of consumer behavior modification implemented next. To overcome these risks, Dallas should continue to invest resources in the update to its strategic water conservation plan and continue to identify and implement best management practices, public awareness and education campaigns that are likely to succeed as technology improves and consumer behaviors change.

Additional Conservation Implementation Steps

- Dallas to update its strategic water conservation plan to identify, fund and implement appropriate BMPs to achieve the planned savings.
- Continue to monitor and document savings achieved from conservation efforts.
- Continue public awareness and education campaigns.

6.5.2 Main Stem Pump Station

Dallas entered into an agreement with NTMWD in 2008, known as the "Swap Agreement", which provides for the exchange of Dallas' Trinity River return flows to NTMWD for diversion and use at NTMWD's East Fork wetlands project in exchange for NTMWD return flows discharged into Lake Ray Hubbard. This Swap Agreement provides an increase in supply of about 31 MGD to Dallas via the impounded return flows in Lake Ray Hubbard. NTMWD experienced severe supply limitations through the 2011-2015 drought, and has decided that construction of the main stem pump station could begin as early as 2016. This is well in advance of Dallas' need for this project. The likely area of risk for this project is the permitting of the Trinity River intake and associated facilities.

Main Stem Pump Station Implementation Steps

- Continue to coordinate with NTMWD on the implementation of this strategy.
- Because the project timeline has shifted due to the immediate need of NTMWD, Dallas and NTMWD may amend the terms of the swap agreement to reflect the new concept and timeline.

6.5.3 Main Stem Balancing Reservoir

The main stem balancing reservoir is an indirect reuse project that will provide Dallas with a strategy to utilize its previously permitted return flows. This project comes with a significant storage component that increases the reliability of the supply. The risks associated with implementing this project generally are associated with permitting and site suitability for construction of a reservoir. A detailed feasibility / permitting effort is recommended that would provide answers and minimize the associated risks. The second component of risk involves the availability of Dallas' return flows. Dallas is currently required by its existing reuse permit to leave 114,000 acft/yr (102) MGD of return flows in the Trinity River for instream uses. However, improvements to its wastewater collection system and implementation of water conservation measures have resulted in a downward trend in wastewater discharges. With growth in the water demands on the City this trend cannot continue indefinitely; however, amending the 102 MGD instream flow requirement could result in additional return flows being made available for diversion subject to the new environmental flow standards in the Trinity River Basin.

Main Stem Balancing Reservoir Implementation Steps

- Initiate a main stem balancing reservoir feasibility study that includes: securing the water rights permit for the storage reservoir, performing a reservoir site foundation evaluation, initiating a land acquisition and maintenance program (prior to construction), preparing a water quality evaluation, performing a siting study of the main-stem pump station considering flooding issues; and determining the need for a new Trinity River water control structure or improvements to an existing structure.
- Being coordination and field work necessary to obtain a Section 404 permit from the USACE.

6.5.4 Integrated Pipeline – Lake Palestine Supply

Dallas has been participating with the TRWD on the development of the IPL for several years. The next step is to re-evaluate the capacity of the Palestine to Cedar Creek segment of the IPL considering the three future recommended strategies that could utilize this capacity (i.e. Lake Palestine, Neches Run-of-the-River and Lake Columbia). There would also need to be an analysis on the shared segments and booster pump stations to determine if the existing IPL segments can handle the extra water and identify any improvements that would be required. Once the delivery capacity has been decided, then the design of the Dallas segments can proceed as well as an additional analysis (as discussed in a subsequent subsection) for Dallas to determine the best way to connect the IPL supply to its water supply system. Fortunately, the main supply for this strategy has previously been secured by Dallas (Lake Palestine). The biggest risk to this strategy is finalizing and implementing the integration plan to deliver this water into the Dallas system from the Joe Pool Lake area to the Bachman WTP.

IPL – Part 1 Connection to Lake Palestine Implementation Steps

- Re-evaluate the planned 150 MGD capacity of the Palestine to Cedar Creek segment of the IPL considering that the combined supply from the three recommended strategies could supply as much as 194 MGD [i.e. Lake Palestine (102 MGD), Neches Run-of-the-River (42 MGD) and Lake Columbia (50 MGD)]. Once the delivery capacity is finalized, proceed with the final design of the Palestine to Cedar Creek pipeline segment of the IPL.
- Determine what metric will initiate the subsequent construction of the Dallas segments of the IPL. The LRWSP assumes that this will be driven by demands on the Dallas western subsystem. This project could also be initiated in response to increasingly severe drought conditions.

IPL – Part 2 Connection to Bachman WTP Implementation Steps

- Initiate a follow-on study to the 2014 LRWSP that results in identifying critical infrastructure components and associated implementation phasing needed to fully integrate the combined 296 MGD of new supply to Dallas' western subsystem. This includes supplies from Lake Palestine (102 MGD), the Main-stem Balancing Reservoir (102 MGD), Neches Run-of-the-River (42 MGD), and Lake Columbia (50 MGD). This follow-on study would consider alternative delivery routes for both pipelines and natural stream systems, potential use of Joe Pool Lake storage or other facilities for meeting balancing needs, water treatment and distribution system improvements needed, water quality and blending issues, and other concerns. This study would consider and include:
    - Coordination with TRA and other stakeholders regarding the potential use of Joe Pool Lake as part of the delivery system for the IPL water considering water quality and blending issues.
    - Development of a Western Subsystem Water Treatment Master Plan which considers the implications of implementing the recommended water supply strategies and associated treatment plant and distribution system improvements.

- Decide on a selected delivery route for the water from the IPL to the Bachman WTP and begin acquiring the necessary permits. Special consideration should be given to the Section 408 permit required for construction activities near a levee.

6.5.5 Neches Run-of-River

Dallas has been participating in a study, Neches River Water Supply Project Feasibility Study, with the UNRMWA for a potential water supply project in the Neches River Basin. This study has been proceeding concurrently with the 2014 LRWSP. The findings of that study have resulted in the inclusion of the Neches run-of-river strategy as a recommended strategy for Dallas. This strategy would supply an estimated 42 MGD to Dallas and would tie-in to Dallas' new IPL facilities at Lake Palestine It is anticipated that the greatest risk to development of this project is securing the required permits, including the inter-basin transfer to the Trinity Basin from the Neches Basin.

Neches Run-of-River Project Implementation Steps

- 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 chosen by Dallas as part of the 2014 LRWSP, 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.

6.5.6 Lake Columbia

ANRA has been developing the Lake Columbia project to meet local needs and provide supply to other entities, such as Dallas. ANRA has secured the water right permit for the project and is currently seeking a 404 permit and going through the Environmental Impact Statement (EIS) portion of National Environmental Policy Act (NEPA) with a third party contractor and the USACE. The permitting effort associated with the mitigation of bottomland hardwoods for this project are significant and are expected to take many years to be completed.

Lake Columbia Implementation Steps

- Partner with the ANRA on the permitting of Lake Columbia including the 404 permitting process and the amendment of ANRA's existing water right to include an interbasin transfer which would authorize Dallas' use of this water in the Trinity River Basin.

6.5.7 Alternative Strategies

The focus of project implementation should be on the recommended strategies as discussed above. However, Dallas should also have a good back up plan in the event one or more of the recommended strategies runs into implementation problems. This back up plan includes the continuation of work on alternative strategies.

The risks associated with pursuing alternative strategies are similar to those listed above for the recommended strategies with permitting and regulatory requirements being the likeliest roadblocks for implementation. The following implementation steps for alternative strategies have been developed for Dallas to continue to pursue these strategies so that, in the event a recommended strategy is determined to no longer be viable, one of more of the alternative strategies could be implemented with minimum lost time.

Alternative Strategies Implementation Steps

- Continue to evaluate the potential for direct non-potable reuse customers in the identified reuse corridor.
- Initiate a feasibility study of the Red River OCR option, as a regional study with other partners, to evaluate the potential for that strategy to develop reliable supply. This study would include analyses on water availability, Red River Compact issues, water quality and invasive species concerns, regional delivery options, and constructability of an intake on the Red River.
- Continue to participate in the Sulphur River Basin study with other regional partners.
- Consider a feasibility study with other regional partners for the conjunctive use of Carrizo-Wilcox groundwater and diversions of Sabine River water to an OCR.
- Consider negotiations with Oklahoma and/or the USACE for access to additional water in Lake Texoma to supply a potential desalination strategy.

6.6 Summary

Dallas initiated the 2014 LRWSP effort in late 2012 with the goal of this effort including the identification, evaluation, and selection of water management strategies that can be implemented to meet Dallas' future water supply needs. Through the planning process Dallas has identified six (6) 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 by partnering with neighboring entities. These strategies have development challenges and overall risks that will need to be overcome through the implementation process. The 2014 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 in 2019 and on a 5-year recurring schedule via an update to the 2014 LRWSP.

As the development of new supplies becomes more challenging from a cost and permitting perspective, more consideration should be given to maximizing the potential for a regional water supply system for the north Texas region that includes Dallas and many, if not all of the other major water providers in the area: NTMWD, TRWD, UTRMWD, TRA, and others. DWU should discuss the potential interest with all major water providers in the North Texas Metroplex area to consider a study to evaluate the benefits and problems of operating all or portions of the region's water supply sources as a single system or subsystems, instead of multiple separate systems.

6.6.1 Innovative Strategies and Thinking Beyond 2070

Throughout the development of the 2014 LRWSP several innovative strategies were considered and evaluated. These innovative strategies included brackish groundwater, aquifer storage and recovery, and/or emerging technologies such as direct potable reuse, ocean desalination, dredging to increase reservoir volume, interstate pipelines, and concepts such as using rail cars to haul water from the East Coast of the United States to Dallas. These and many others were evaluated on the same footing as the more traditional strategies recommended in the plan, but did not score well due to cost, limited supply, or other factors. However, as technology improves and costs come down perhaps some of these innovative approaches will be part of the next Dallas LRWSP.

The 2014 LRWSP identified numerous strategies available to meet significantly more than Dallas' demand in 2070 with a combination of several alternative strategies being able to provide another 800 MGD.

7 Water Management 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. For the 2014 LRWSP, the HDR Team developed a screening methodology which utilized a strategy evaluation matrix to assist Dallas in the selection of recommended and alternative water management strategies (strategies) to meet Dallas' future needs. This methodology and evaluation matrix were used to: 1) identify and define all possible strategies, 2) eliminate non-feasible or non-practicable strategies from further consideration, 3) rank the remaining strategies based on a set of quantitative and qualitative criteria, and 4) select the recommended and alternative strategies for inclusion in the 2014 LRWSP.

Section 7.1 describes the process used to identify, score, rank and select Dallas' recommended and alternative strategies which are also referred to as preferred strategies. Sections 7.2 through 7.14 include detailed evaluations for all recommended and alternative strategies. Appendix K contains a set of facts sheets that summarize key characteristics of Dallas' preferred strategies.

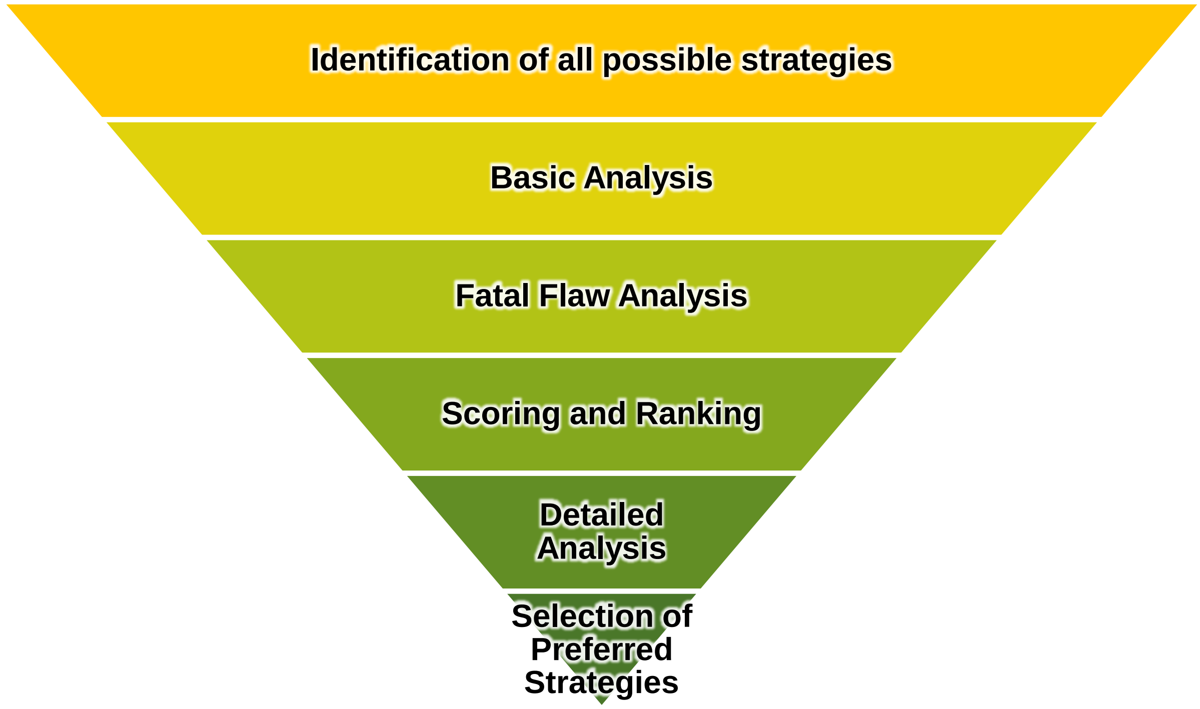
7.1 Strategy Selection Process

A structured process was utilized to select the preferred strategies for inclusion in the 2014 LRWSP. Figure 7.1-1 illustrates the steps used for this process. Each step resulted in the elimination of strategies that were determined to be non-feasible and/or non-practicable for Dallas. The process starts with the identification of all possible strategies and ends with a list of preferred strategies from which recommended and alternative strategies are then selected. This process included:

- Strategy Identification – The identification of potential strategies from previous studies and plans as well as developing new strategies for consideration.
- Preliminary Evaluation – Refinement and additional analyses of previously studied strategies to establish comparable cost, yield and impact data.
- Fatal Flaw Analysis – The elimination of strategies that are determined to be no longer feasible.
- Scoring and Ranking – Using quantitative and qualitative criteria, a unique score is determined for each strategy that is then used to rank each strategy.
- Detailed Evaluation – Remaining strategies are evaluated in more detail to better define scoring characteristics.
- Selection of Preferred Strategies – Highest ranked strategies are selected as preferred strategies (recommended and alternative) for inclusion in the 2014 LRWSP.

Throughout the selection process new details are discovered, costs and impacts are refined, and available yields are updated, all of which are considered in the selection of the preferred strategies.

Figure 7.1-1. Flow Chart Summarizing the Process of Selecting Preferred Strategies



7.1.1 Strategy Identification

Over 300 strategies were initially identified as possible water management strategies for Dallas. This conglomeration of strategies included strategies identified in numerous previous studies including Dallas' 2005 LRWSP and numerous state water plans published between 1968 and 2012. Also included were updates to previously identified strategies and new strategies identified and evaluated as part of the 2014 LRWSP. A table listing these 300 plus strategies is included in Appendix L. Note that several strategies appear multiple times in the table as they were included in several different studies. During the strategy selection process these duplicates were refined and consolidated as appropriate.

7.1.2 Preliminary Evaluation and Fatal Flaw Analysis

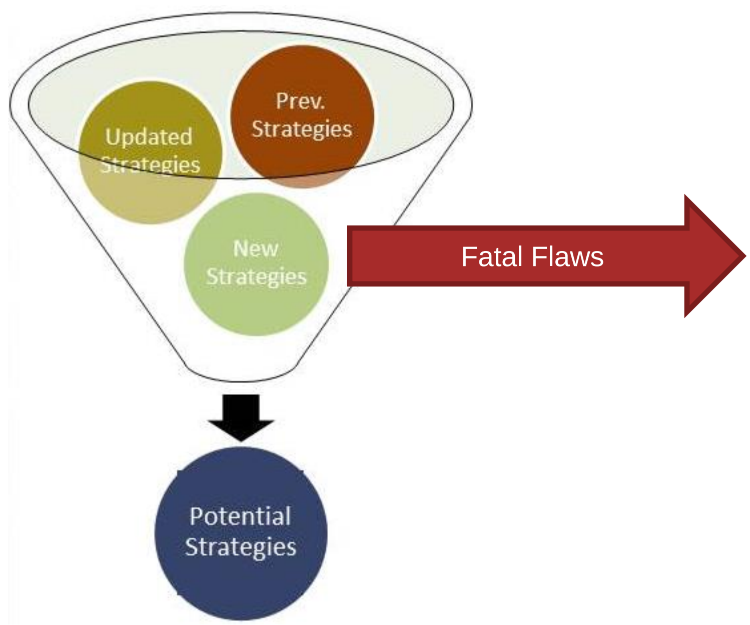
Each of the initially identified strategies was evaluated at a basic level to compare costs, available supply, and potential for a fatal flaw. Few strategies were eliminated strictly on a fatal flaw basis. Most were eliminated as a result of being out of date, a duplicate strategy, or being implemented by another entity. The fatal flaw analysis was performed to eliminate strategies that were considered no longer feasible or practicable. There were six different reasons for excluding a strategy from further analysis during the fatal flaw analysis and these included:

- Fatal Flaw (FF) – Identification of an issue that prevents the project from being implemented (e.g. establishment of a nature preserve in the footprint of a proposed reservoir).

- Out of Date (OOD) – Strategy that has been replaced by another project, has been implemented or is no longer feasible.
- Duplicate – (DUP) Strategies that are effectively duplicates of one another or that use the same water source, or where one is more up to date.
- Insufficient Data (INSF) - Not enough data exists to define strategy for consideration.
- Not a Dallas Strategy (NADS) - Strategy has been implemented or is being pursued by another entity.
- Not recommended for Further Study (NRFS) - Strategy excluded because of poor water quality, lack of sufficient supply, poor reliability, very high costs or impact or other reason.

Figure 7.1-2 represents the fatal flaw process graphically. The results of the fatal flaw analysis reduced the 300 plus possible strategies down to 41 potential strategies. These 41 strategies were next evaluated using the following screening criteria.

Figure 7.1-2. Diagram of Fatal Flaw Analysis for Selection of Potential Strategies



7.1.3 Screening Criteria

To further evaluate and rank the remaining 41 potential strategies, two types of screening criteria were developed and used to provide a quantitative approach of ranking the potential strategies. These included four basic criteria and four advanced criteria.

The four basic criteria include total project cost, unit cost, annual operational and maintenance costs, and annual water supply volume. All cost estimates were updated to September 2013 dollars for consistency with the 2016 Region C RWP. Table 7.1-1 summarizes the basic 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 20^{th} percentile when ranked against all of the other potential strategies, then that strategy would receive a score of 5 for the total project cost criteria.

Table 7.1-1. Summary of Basic Screening Criteria

Criteria	Description	Scoring Value				
		1	2	3	4	5
Total Project Cost	The total project costs for all project components.	1st Quintile	2st Quintile	3st Quintile	4st Quintile	5st 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					

Four advanced screening criteria were developed and used to allow for the inclusion of criteria focusing on potential project impacts and implementation challenges. These included environmental impacts, permitting issues/legal challenges/confidence, flexibility/phasing, and water quality. Table 7.1-2 summarizes the advanced screening criteria and provides descriptions for each scoring value. Identical to the basic criteria scoring, values range from 1 to 5 with 5 being the most favorable score and 1 being the least favorable score. Quantitative guidelines are also provided in Table 7.1-2 and are used to ensure consistency in the scoring process. Unlike the basic criteria, the advanced screening criteria allow each strategy to be scored independently from the other strategies, resulting in the relative score not being influenced by the other strategies.

7.1.4 Strategy Evaluation Matrix

The next step in the strategy selection process included entering the score for each screening criteria into the strategy evaluation matrix. The strategy evaluation matrix is the tool used for the screening analysis. An evenly weighted distribution factor was applied to all 8 criteria so that a maximum score of 250 points could be achieved by a strategy that scores a 5 in all 8 criteria (i.e. 5 X 8 X 6.25 = 250). The 250 maximum score was selected to show a reasonable degree of variation between the strategies during the ranking process.

Table 7.1-2. Summary of Advanced Screening Criteria

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

Table 7.2-2 Summary of Advanced Screening Criteria (cont.)

FLEXIBILITY/PHASING		
Scoring Value	**Description**	**Quantitative 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 configuration and multiple delivery points. Minimal reliability concerns. Favored source (Reuse).

7.1.5 Screening Results

Figure 7.1-3 through Figure 7.1-5 present the screening results for all of the potential 41 strategies. The strategies are color coded according to the type of strategy, e.g. existing reservoir, conservation, reuse, etc. Basic criteria scores are represented by solid bars and advanced criteria scores are represented by hashed bars. Strategy abbreviations are used in Figure 7.1-3 through Figure 7.1-5 with full strategy names corresponding to the strategy abbreviations provided in Appendix M.

Figure 7.1-3 presents the basic criteria scoring for all 41 of the potential strategies. The basic criteria scoring results show that reuse and groundwater strategies scored higher, with new reservoirs and pipelines to existing reservoirs scoring lower. The reuse strategies typically had higher scores because of the close proximity to Dallas, thus reducing transmission costs, and lower infrastructure and land acquisition costs. Likewise, the groundwater strategies tend to have lower infrastructure and land acquisition costs, resulting in higher basic criteria scores. The new and existing reservoir strategies typically have longer transmission distances and greater land acquisition and infrastructure costs compared to the reuse and groundwater strategies. As a result of the basic criteria scores being based on comparisons with the other strategies, the new and existing reservoir strategies received lower scores. 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 basic 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 basic criteria rankings.

Figure 7.1-4 presents the scoring results for the advanced criteria. The resulting ranking of strategies based on the advanced criteria is similar to the rankings of the basic criteria scoring results. 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, there are two exceptions. The IPL strategy and the Main Stem Balancing Reservoir strategy both ranked very high in the advanced criteria scoring. The IPL received higher scores because several of the necessary permits have already been acquired and because the strategy has high potential for flexibility and phasing. The Main Stem Balancing Reservoir strategy received higher scores because the strategy has a reuse component with lower permitting challenges and a high potential for flexibility and phasing similar to the IPL strategy.

Figure 7.1-3. Basic Score for Potential Strategies

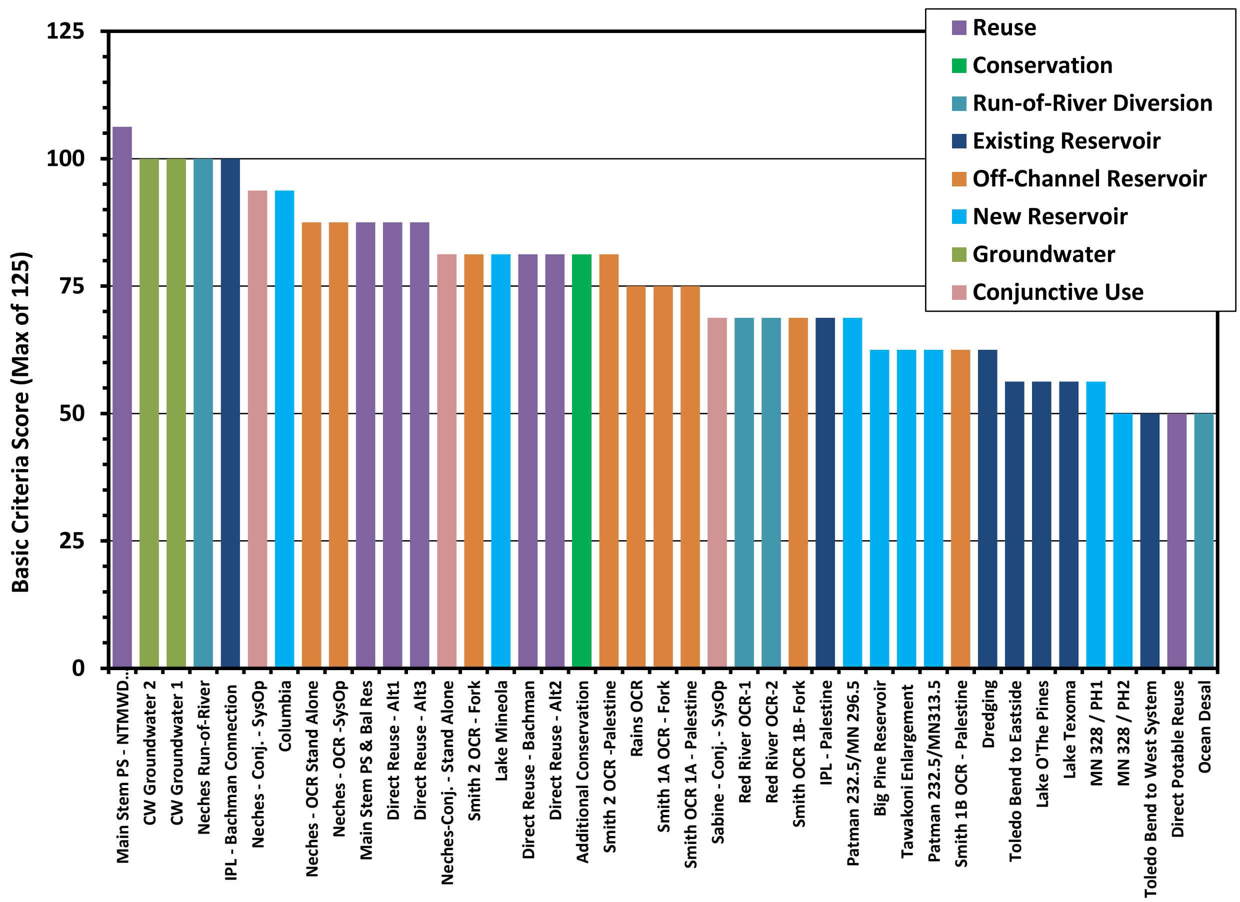


Figure 7.1-4. Advanced Score for Potential Strategies

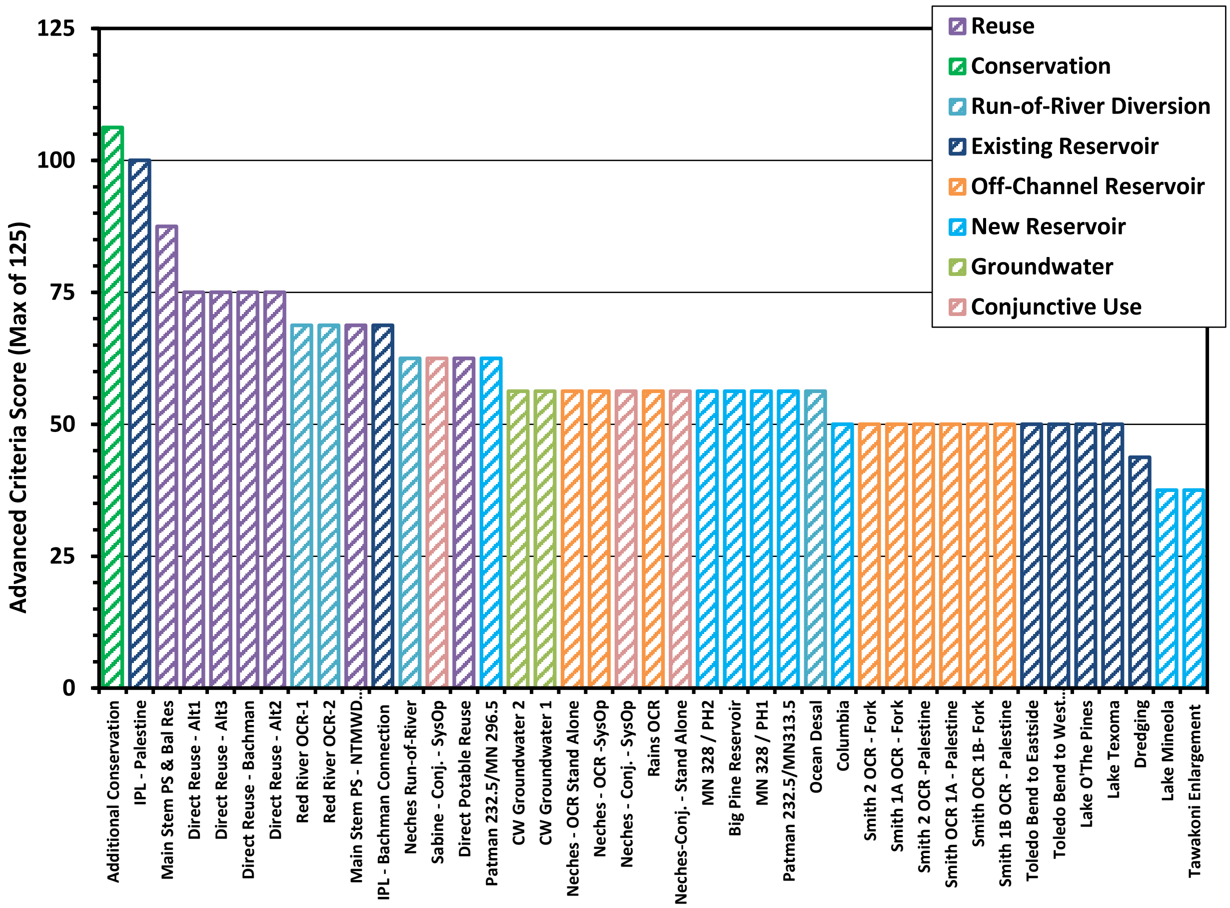


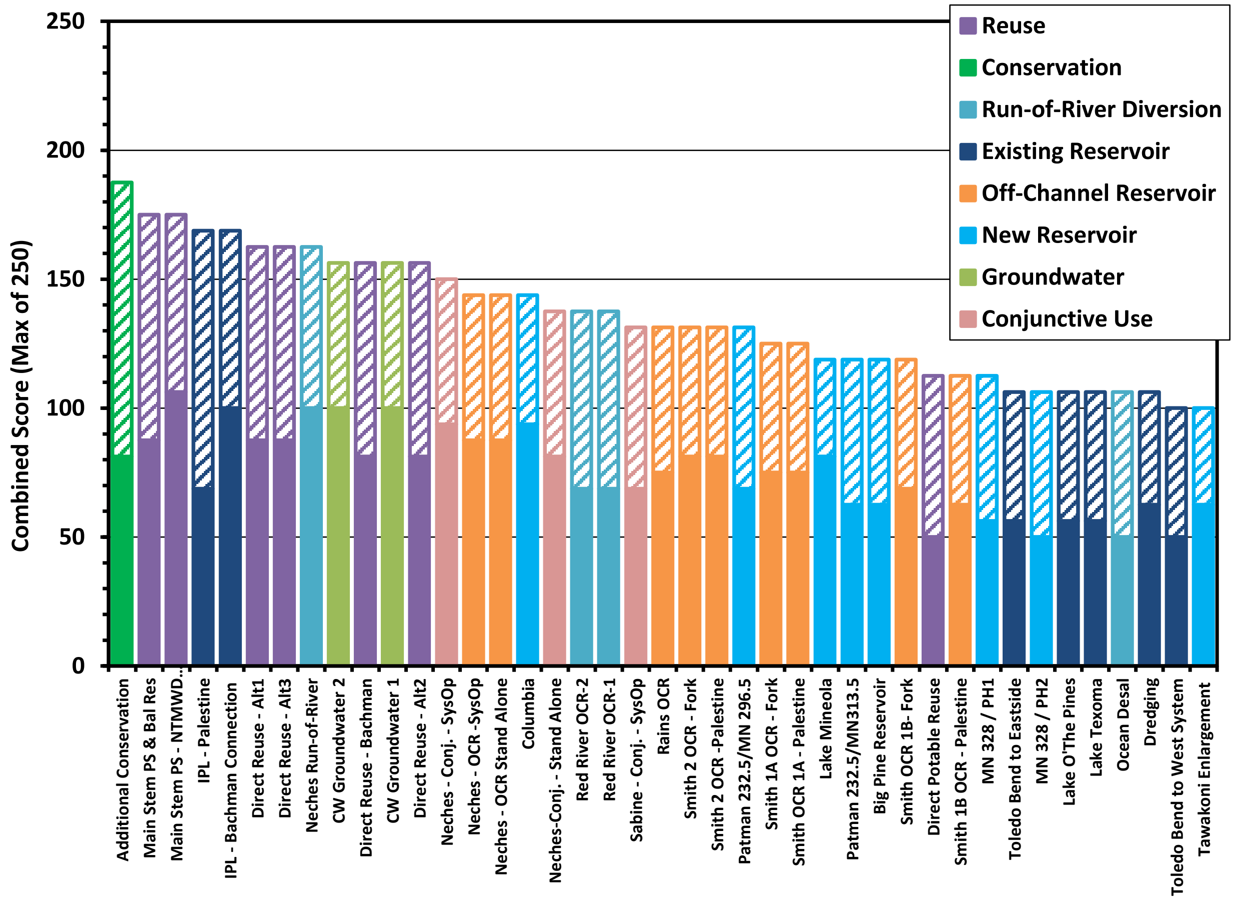
Figure 7.1-5 presents the combined scoring results for all 41 potential strategies. The ranking order shows that the Main Stem Pump Station strategy which includes an exchange of return flows with North Texas Municipal Water District (NTMWD) and additional conservation are the two highest ranked strategies. These strategies are followed by several reuse strategies and the IPL strategy. The lower end of the ranking is comprised mostly of new and existing reservoir strategies.

As previously discussed, the combined ranking results reveal that reuse strategies are some of the highest rated potential strategies. However, most of the reuse strategies provide small volumes of supply compared to the other strategies and would fall short in meeting Dallas' future needs. The total combined score of each strategy was considered in selecting strategies to meet Dallas' future water supply needs.

7.1.6 Preferred Strategies

The total combined score for each of the 41 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. For example, additional conservation is the highest ranked potential strategy and is an easy selection to be a preferred strategy. Similarly, the Main Stem Pump Station project in cooperation with the NTMWD and the Main Stem Balancing Reservoir both ranked high and are recommended to be included in the list of preferred strategies.

Figure 7.1-5. Combined (Basic and Advanced Scores) of Potential Strategies



The two components of the IPL (Lake Palestine and the Bachman Connection) likewise scored high due, in part, to Dallas' previous investments in these strategies and are recommended.

However, the next strategies are the direct non-potable reuse strategies (Direct Reuse – Alt 1, etc.) identified from the Bureau of Reclamation study[1]. A close look at these strategies reveals that only one of these strategies can be implemented as all these strategies are essentially different configurations of the same supply. For this reason, only the highest ranked Direct Reuse - Alt1 was selected as a preferred strategy. Similar analyses were performed for all the remaining potential strategies to develop the list of preferred strategies.

The 2014 LRWSP strategy evaluation and ranking process resulted in a list of 14 preferred strategies. These 14 preferred strategies rose to the top of the rankings and were selected after over 300 strategies were considered. Table 7.1-3 provides a summary of the preferred strategies including the projected supply quantity and estimated unit cost associated with each. Detailed evaluations of each preferred strategy are presented in Subsection 7.2 through 7.14. Project facts sheets for each preferred strategy are presented in Appendix K.

[1] *Dallas Reclaimed Water Delivery System Feasibility Study,* Dallas Water Utilities, City of Dallas, TX. U.S. Department of the Interior, Bureau of Reclamation, December 2013.

Table 7.1-3. Preferred Strategies – Summary of Projected Supply and Unit Cost

Strategy Name	2070 Projected Supply (MGD)	Unit Cost ($/1,000 gal)
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 [a]	-	$2.31
IPL Part 2 – Connection to Bachman WTP [a]	-	$0.49
Direct Reuse – Alternative 1	2.23	$2.24
Carrizo Wilcox Groundwater (Alternative 2)	26.7	$1.80
Neches Run-of-River	42.2	$1.88
Lake Columbia	50.0	$1.78
Sabine – Conjunctive Use (OCR and groundwater)	93.0	$2.27
Red River OCR	102	$2.27
Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5) [b]	102	$2.28
Toledo Bend Reservoir	179	$3.14
Lake Texoma Desalination	130	$3.54

[a] Note that there are two components to the IPL strategy and that both are required to be implemented for Dallas to receive the additional supply of 102 MGD. The unit cost shown here include Dallas' portion of the project necessary to deliver water to the Dallas system.

[b] At the time of the Dallas City Council adoption of the recommended strategies the draft Sulphur Basin Wide Study identified reservoir elevations to determine yield and cost. Additional studies will be necessary to identify specific project elevations / configurations.

7.1.7 Recommended & Alternative Strategies

The 14 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. 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 2014 LRWSP. The recommended strategies are listed in Table 7.1-4. The remaining strategies are referred to as alternative strategies and are listed in Table 7.1-5. These alternative strategies 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. Table 7.1-6 provides a summary of the 14 strategies and the associated characteristics which were evaluated as part of the 2014 Dallas LRWSP, this table is also contained in Appendix K.

Table 7.1-4. Recommended Strategies for Dallas

Recommended Strategy
Additional Conservation
Indirect Reuse Implementation Main Stem Pump Station – NTMWD Swap Agreement Main Stem Balancing Reservoir
Connect Lake Palestine through the IPL Part 1 - Connection to Lake Palestine Part 2 - Connection to Bachman WTP
Neches Run-of-River
Lake Columbia

Table 7.1-5. Alternatives Strategies for Dallas

Alternative Strategy
Direct Reuse – Alternative 1
Carrizo Wilcox Groundwater (Alternative 2)
Sabine – Conjunctive Use (OCR and groundwater)
Red River OCR
Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5)
Toledo Bend Reservoir
Lake Texoma Desalination

7.1.8 Costing Methodologies and Assumptions

The 2014 Dallas LRWSP relied on the TWDB Unified Costing Model (UCM) to develop planning level cost estimates for new and updated strategies in order to compare strategies on a similar basis for cost. However, if a strategy already had a more detailed or recent estimate (such as the IPL strategies) or is the result of another ongoing study (Sulphur Basin Project) those estimates were used in the 2014 Dallas LRWSP and formatted to be comparable with the other estimates using the UCM. For the development of the 2016 Regional Water Plans the TWDB stipulated that all strategies would use September 2013 dollars, and this assumption has been used in the LRWSP except where noted in the strategy write ups.

Appendix O contains additional information regarding the assumptions, methodologies, and the UCM used to develop the planning level estimates contained in the 2014 Dallas LRWSP. The cost tables shown in this report are based on detailed worksheets with multiple line item values. For purposes of presenting this information in the report, this detailed information has been summarized with aggregated and rounded values. In other words there is additional detail contained in the estimate that is not presented in the Section 7 cost summary tables. The values in the summary tables are rounded based off of the detailed costing model values. This is similar to how cost estimates are shown in the Regional Water Plans.

Table 7.1-6. Recommended and Alternative Strategy Characteristic Summary

Description			Environmental Impacts (Qualitative Assessment - Level of Concern)						Dallas Portion of Cost (if shared or regional project)			
Strategy	Selection	Supply (MGD)	Habitat	Env. Water Needs	Bay and Estuary	Threatened and Endangered	Wetland	Agriculture and Natural Resources	Total Project ($ Millions)	Annual ($ Millions)	Unit ($/acft)	Unit ($/1,000 gal)
Additional Conservation	Rec.	46.4	None	None	None	None	None	None	51.7 [b]	$6.42	$123.50	$0.38
Main Stem Pump Station - NTMWD Swap Agreement	Rec.	31.1	Low	Low	Low	Low	Low	Low	$26.11	$2.88	$83	$0.25
Main Stem Balancing Reservoir	Rec.	102	Low	Low	Low	Low	Low	Low	$674.46	$64.89	$568	$1.74
IPL Part 1 - Connection to Lake Palestine	Rec.	102 [a]	Low	Low	Low	Low	Low	Low	$938.95	$85.90	$751	$2.31
IPL Part 2 - Connection to Bachman WTP	Rec.	102 [a]	Low	None	None	Low	Low	Low	$244.32	$18.20	$159	$0.49
Neches Run of River	Rec.	42	Low	Low	Low	Low	Low	Low	$226.79	$28.97	$613	$1.88
Lake Columbia	Rec.	50	High	Medium-High	Low	Low	High	Low	$288.64	$32.55	$581	$1.78
Direct Reuse - Alternative 1	Alt.	2.2	None	None	None	Low	None	None	$27.43	$1.83	$731	$2.24
Carrizo Wilcox Groundwater (Alternative 2)	Alt.	27	Low	None	None	Low	Low	Low	$161.06	$17.61	$587	$1.80
Sabine - Conjunctive Use (OCR and groundwater)	Alt.	93	Low	Low	Low	Low	Low	Low	$795.82	$77.12	$740	$2.27
Red River OCR	Alt.	102	Low	Low	Low	Low	Low	Low	$852.99	$84.19	$738	$2.27
Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5)	Alt.	102	High	Medium-High	low	Medium	High	Medium	$1,003.14	$84.64	$742	$2.28
Toledo Bend Reservoir	Alt.	178	Medium	Medium	Medium	Low	Low	Low	$2,290.07	$204.71	$1,024	$3.14
Lake Texoma Desalination	Alt.	130	Low	Low-Medium	Low	Low	Low	Low	$1,382.14	$168.41	$1,153	$3.54

[a] Both IPL Part 1 and Part 2 are required for Dallas to obtain the 102 MGD supply.

[b] Calculated equivalent total project cost using a net present value analysis, see Section 7.2.6 for detail.

7.2 Additional Water Conservation

7.2.1 Introduction

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)).

Because the City of Dallas holds water rights in excess of 1,000 acft/yr, the State of Texas in 30 Texas Administrative Code, Chapter 288 requires that the City of Dallas develop, 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 Strategic Plan* (the “Strategic Plan”). The Strategic Plan is updated approximately every five years, as required by the state. The current version was completed in 2010 and the development of the 2015 version is currently underway. The Strategic Plan includes a list of Best Management Practices (BMPs) and policy recommendations that are developed through detailed analysis and stakeholder input. The Strategic Plan contains detailed analyses of an exhaustive list of potential water conservation strategies (or BMPs) 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 Strategic Plan and presents an analysis of water conservation strategies adopted for implementation by DWU. Both of these plans provide a wealth 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 February 26, 2014.

Conserving existing water supplies through demand reduction can be one of the most cost-effective strategies available to municipal water suppliers to extend available supply. The purpose of this section is to consider quantitative conservation goals applicable over the 50-year planning timeframe of the 2014 LRWSP and to provide ideas on how this goal could potentially be met through strategies that are identified as part of Dallas’ Strategic Plan and Water Conservation Plan.

7.2.2 Plumbing Code Reductions

In 2009, the 81st Texas State Legislature passed HB 2667 (commonly referred to as the “Plumbing fixtures act”) which mandates local building codes require the use of low-flow and high-efficiency plumbing fixtures for all new or retrofitted construction by 2014. The mandatory use of these fixtures is expected to reduce the average per capita water use for the City of Dallas and its customers by 8.7% over the 50 year planning period[1]. The water demand projections presented in Section 4 include this 8.7% reduction in future per capita consumption.

7.2.3 City of Dallas Water Conservation Goals

Table 7.2-1 presents future estimates of per capita water (gpcd) use for the City of Dallas (excluding the City's wholesale customers) based on both the TWDB's projections (to be used in both the 2016 Region C RWP and the 2014 LRWSP) and recommended 50-year water conservation targets based on Dallas' continuing efforts to reduce water use. These recommended conservation targets are generally consistent with both the Strategic Plan and the Water Conservation Plan. The additional reduction in per capita water use resulting from using the recommended values rather than the TWDB's estimates reflects the potential additional conservation savings as a result of Dallas' conservation targets being achieved.

Dallas' 2011 gpcd value as determined by the TWDB of 207 is used as the starting point for developing demand projections and for projecting recommended additional conservation savings in the 2014 Dallas LRWSP. The reduced water use associated with the additional conservation savings is calculated by reducing per capita water use by 1.0% per year until 2025. Beginning in 2026, the gpcd value is reduced at the rate of 0.5% per year until 2043 to reflect a reduced conservation rate as per capita use rates begin to harden due to previous conservation measures. Beginning in 2043, the per capita water use rate is stabilized at 164. This represents a reduction in per capita use of 43 gpcd or about 21% from the 2011 baseline gpcd value of 207.

As shown in Table 7.2-1 and Figure 7.2-1, the annual volume of water saved under the additional conservation savings strategy is estimated to be 10.9 MGD in 2020 (12,219 acft/year) and 46.4 MGD in 2070 (52,014 acft/year). This represents a potential additional reduction in water use by the City of Dallas of 4.4% in 2020 and 12.9% in 2070 as compared to the TWDB's baseline projections.

7.2.4 Water Conservation Goals for City of Dallas' Wholesale Customers

It is important to note that Dallas has much less control over conservation measures taken by its wholesale customers, so there is a significant degree of uncertainty regarding whether additional conservation savings would occur over the planning period. Current contracts between the City of Dallas and wholesale customers contain the following typical provisions related to water conservation:

1. The customer agrees to develop a water conservation plan and like measures which incorporates loss-reduction measures and demand management practices designed to ensure that the available supply is used in an economically efficient and environmentally sensitive manner, and
2. If Dallas grants authorization for the customer to sell water purchased from Dallas, then Dallas may establish the terms and conditions of the conveyance.

[1] 2016 Region C Regional Water Plan. Projected per capita use for the City of Dallas, Texas.

During the Region C planning process, estimated conservation amounts were determined for the City of Dallas customers; however, they are not included as part of this strategy due to the uncertainties discussed above and Dallas' limited ability to control the conservation efforts of its customer cities.

Table 7.2-1. Estimated Reduction in City of Dallas Water Demands with Additional Conservation Strategy

Component	2020	2030	2040	2050	2060	2070
Dallas Population Projections	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498
TWDB Projected gpcd **(2011 TWDB baseline = 207 gpcd)**	198	194	191	189	189	189
TWDB Projected Water Demand (MGD)	245.6	260.8	291.6	322.5	347.2	359.3
Recommended gpcd with Additional Conservation (2014 LRWSP)	189	175	167	164	164	164
Projected Water Demand w/ Additional Conservation – (MGD)	234.7	236.2	255.3	280.3	302.3	312.9
Additional Conservation Savings (MGD)	10.9	24.6	36.3	42.2	44.9	46.4
Percentage Decrease in Water Demand with Additional Conservation	4.4%	9.5%	12.4%	13.1%	12.9%	12.9%

Note: The TWDB established a per capita use of 207 gpcd for Dallas for the year 2011 which serves as the baseline value for determining the estimated reductions presented in this table. Values in the table are rounded to the nearest 0.1 MGD.

7.2.5 Strategies to Achieve Recommended Water Conservation Goal

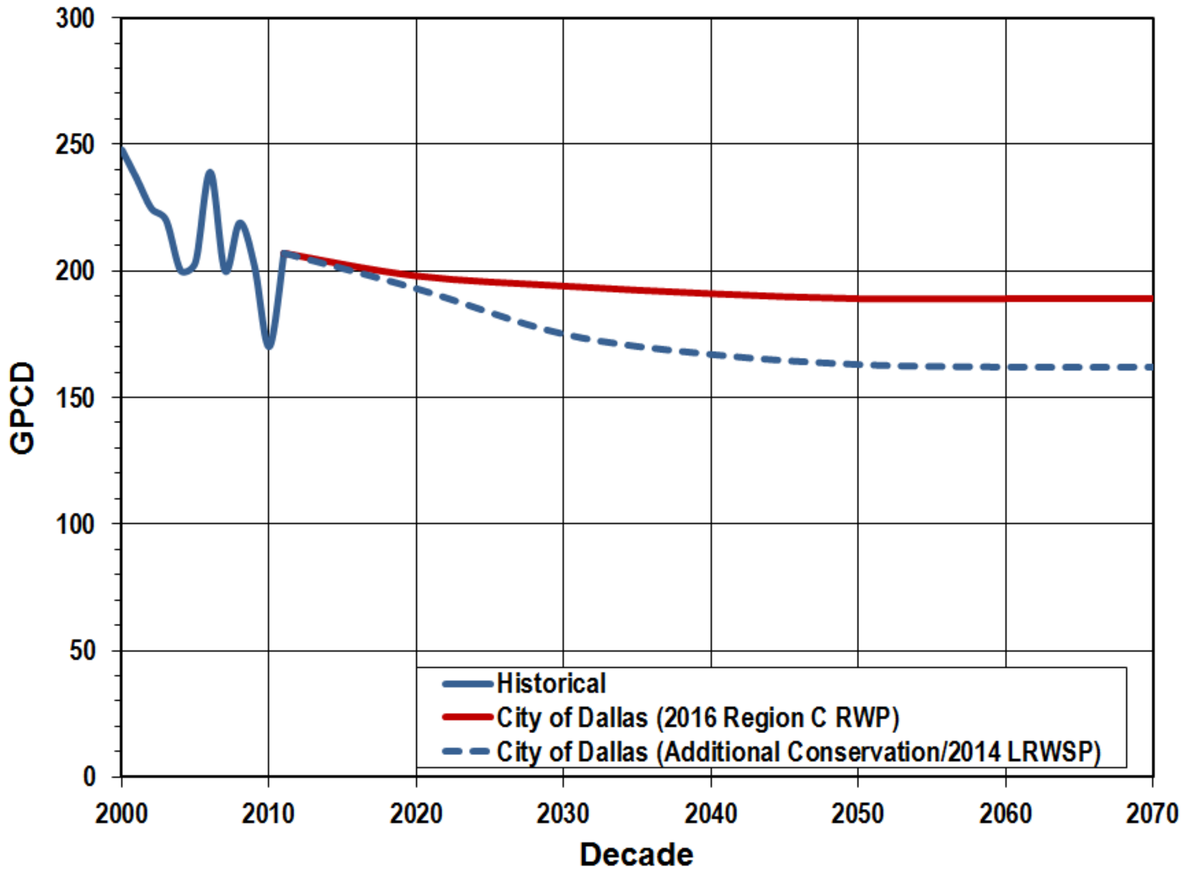
Water conservation savings are achieved through the synergy of technology, education, ordinances and incentives. The Strategic Plan and the Water Conservation Plan both recommend that water conservation savings be derived from a combination of education, rates, irrigation efficiency and restrictions, non-residential efficiency, reuse and reduced system losses.

The City of Dallas 2010 Water Conservation Strategic Plan and 2014 Water Conservation Plan include the following goals,:

- Develop water conservation programs aimed at:
  - developing and implementing programs aimed at reducing seasonal peak demands,
  - reducing water loss and waste, and
  - decreasing per capita water use (gpcd),
- Continuation of heightened public awareness of water conservation,
- Continue to implement conservation practices that will maintain quality of life and allow economic growth and development,

- Continue to implement broad-based public and private stakeholder groups, leading by example by upgrading city facilities with water-efficient fixtures, landscapes, and irrigation systems wherever possible,
- Assist in facilitating regional conservation efforts among DWU wholesale customer cities and neighboring municipalities, and
- Establish the foundation for continuation of water savings targets for the following five-year period and beyond.

Figure 7.2-1. Comparison of Per Capita Water Use Goals for the City of Dallas



The Strategic Plan anticipates that additional conservation savings will be derived by continuing current programs outlined in the previous section, as well as the following items, some of which have already been implemented:

- Expand the public awareness campaign,
- Offer Industrial, Commercial, and Institutional (ICI) water audits,
- Conduct training for ICI facilities managers and licensed irrigators,
- Offer ICI business partnership program for top water users,
- Offer ICI hospitality program for hotels and restaurants,

- Implement Water-wise landscape design requirements limiting turf areas and types of landscaping in new landscapes,
- Implement ICI equipment rule for retrofits in new and newly-occupied ICI establishments,
- Offer residential irrigation system rebates,
- Offer ICI rebates for retrofits and upgrades,
- Enforce new State maximum flow-rate requirements for plumbing fixtures,
- Include conservation clause in all wholesale contracts, and
- Continue coordination with regional water planning group.

In order for Dallas to achieve the anticipated 46.4 MGD additional water conservation savings, as calculated for the 2014 Dallas LRWSP, by 2070, the following are potential additional conservation strategies that may be considered:

- <u>Increasing irrigation water use restrictions</u>: As indicated in the Strategic Plan, residential outdoor water use represents about 37 percent of Dallas residential water use based on analysis of all single family water user accounts. Outdoor water use can be reduced with more efficient landscaping and irrigation technology. In addition, irrigation systems require regular maintenance to maintain efficiency; otherwise they can also become water wasters.
- <u>Improving water use efficiency for industrial, commercial, and institutional properties</u>: Industrial, Commercial, and Institutional (ICI) audits and incentives, such as those proposed in the 2010 Strategic Plan and 2014 Water Conservation Plan can help reduce inefficient water uses within commercial, industrial, and institutional properties. The Strategic Plan estimates that almost 31 percent of DWU water users can be categorized as commercial and industrial with outdoor water use averaging about 40 percent of Dallas commercial water use. Thus landscape design and irrigation efficiency offer significant potential for reducing non-residential water use. As with residential properties, education, public awareness and strategic partnerships, and incentives are needed to maintain realized and projected gains in water use efficiency.
- <u>Improved leak detection and line replacement</u>: Regular leak detection and line replacement is required to maintain water distribution system efficiency. DWU's operations division has an on-going program for water loss control. H.B. 857, passed during the 2013 Texas legislative session, requires retail water suppliers with more than 3,300 connections to submit an annual water loss audit to the TWDB. DWU is required to submit water loss audits under this law which help track performance in managing and controlling apparent losses (e.g., billing and metering errors) and real losses (e.g., leaks).

Additionally, the 46.4 MGD projected water savings for the recommended additional water conservation strategy assumes that:

- Incentive programs will be continued to replace inefficient fixtures until a saturation point has been reached,
- New targets for commercial water use efficiency will emerge, considering new methods and equipment to achieve additional water savings, and
- Emerging new technologies will introduce new opportunities for residential, commercial and industrial water efficiency in the future, and
- Marginally cost-effective water efficiency programs will become more cost-effective to implement over time as the cost of water increases.

7.2.6 Cost Analysis for Additional Conservation

The City of Dallas 2010 Water Conservation Strategic Plan provides probable costs associated with the potential programs needed to achieve the projected conservation savings that total approximately $38 million dollars over the five-year implementation period[2]. Estimated savings from these programs are about 100 billion[3] gallons over the next twenty years. Thus, these savings are estimated to cost about $380 per million gallons (MG), or approximately $123.50 per acft ($0.38/1,000 gallons)[4]. These costs do not include avoided costs related to water supply strategies/infrastructure that can be delayed as a result of reduced water demand. The $123.50 per acft is the unit cost shown for additional conservation in the 2014 LRWSP to compare against other strategies. As conservation savings become more challenging to achieve, this unit cost will likely increase. For comparison purposes, the 2016 Region C Plan assumes a cost of $205/acft[5] ($0.63/1,00 gal) for conservation for Dallas, which is based off TWDB planning assumptions.

To compare the additional conservation strategy to other strategies in the LRWSP a present value analysis was performed to estimate an equivalent total project cost. This total project cost represents what the total project cost of a project that could produce an equivalent volume of supply, in this case 46.4 MGD, given the annual payments associated with the conservation savings over the 50-year life of the plan. This value does not represent the true cost of conservation, but rather the cost of developing a project to produce a similar volume of water. Table 7.2-2. illustrates the methodology used to calculate the net present value (NPV) in 2013 dollars of 50 years of Dallas' conservation plan (2020 – 2070). The result of the NPV analysis showed that Dallas' proposed conservation plan equates to a total project cost of $51.7 million dollars. In other words, Dallas' investment in additional conservation is roughly equivalent to developing a new water supply project with a total project cost of $51.7 million dollars that produces about 46.4 MGD.

[2] City of Dallas Water Conservation Five-Year Strategic Plan, Updated June 2010. Page 9-19.
[3] Ibid. Page 9-7, Appendix K, K-2.
[4] Ibid. Page 9-19.
[5] 2016 Region C Water Plan. Texas Water Development Board, Table 5C.2 on page 5C.15. 2015.

Table 7.2-2. Net Present Value Analysis for Additional Conservation

Year	Conservation Savings (MGD)	Annual Cost ($)	Net Present Value (2013 Dollars)	Cumulative Net Present Value (2013 Dollars)
2020	10.9	$ 1,509,034.15	$1,154,614	$1,154,614
2021	12.27	$ 1,698,701.75	$1,231,976	$2,386,590
2022	13.64	$ 1,888,369.34	$1,298,135	$3,684,725
2023	15.01	$ 2,078,036.94	$1,354,047	$5,038,771
2024	16.38	$ 2,267,704.53	$1,400,601	$6,439,372
2025	17.75	$ 2,457,372.13	$1,438,621	$7,877,993
2026	19.12	$ 2,647,039.72	$1,468,870	$9,346,863
2027	20.49	$ 2,836,707.32	$1,492,056	$10,838,919
2028	21.86	$ 3,026,374.91	$1,508,832	$12,347,750
2029	23.23	$ 3,216,042.51	$1,519,803	$13,867,553
2030	24.6	$ 3,405,710.10	$1,525,530	$15,393,083
2031	25.77	$ 3,567,689.00	$1,514,773	$16,907,857
2032	26.94	$ 3,729,667.89	$1,500,992	$18,408,849
2033	28.11	$ 3,891,646.79	$1,484,531	$19,893,379
2034	29.28	$ 4,053,625.68	$1,465,706	$21,359,085
2035	30.45	$ 4,215,604.58	$1,444,810	$22,803,895
2036	31.62	$ 4,377,583.47	$1,422,109	$24,226,004
2037	32.79	$ 4,539,562.37	$1,397,848	$25,623,851
2038	33.96	$ 4,701,541.26	$1,372,251	$26,996,103
2039	35.13	$ 4,863,520.16	$1,345,525	$28,341,628
2040	36.3	$ 5,025,499.05	$1,317,855	$29,659,483
2041	36.9	$ 5,108,565.15	$1,269,799	$30,929,282
2042	37.5	$ 5,191,631.25	$1,223,172	$32,152,454
2043	38.1	$ 5,274,697.35	$1,177,955	$33,330,408
2044	38.7	$ 5,357,763.45	$1,134,128	$34,464,537
2045	39.3	$ 5,440,829.55	$1,091,670	$35,556,207
2046	39.9	$ 5,523,895.65	$1,050,556	$36,606,763
2047	40.5	$ 5,606,961.75	$1,010,762	$37,617,525

Table 7.2-2. Net Present Value Analysis for Additional Conservation (Cont.)

Year	Conservation Savings (MGD)	Annual Cost ($)	Net Present Value (2013 Dollars)	Cumulative Net Present Value (2013 Dollars)
2048	41.1	$ 5,690,027.85	$972,262	$38,589,787
2049	41.7	$ 5,773,093.95	$935,029	$39,524,815
2050	42.3	$ 5,856,160.05	$899,036	$40,423,851
2051	42.56	$ 5,892,155.36	$857,404	$41,281,255
2052	42.82	$ 5,928,150.67	$817,670	$42,098,925
2053	43.08	$ 5,964,145.98	$779,749	$42,878,674
2054	43.34	$ 6,000,141.29	$743,559	$43,622,234
2055	43.6	$ 6,036,136.60	$709,024	$44,331,257
2056	43.86	$ 6,072,131.91	$676,068	$45,007,325
2057	44.12	$ 6,108,127.22	$644,621	$45,651,947
2058	44.38	$ 6,144,122.53	$614,616	$46,266,563
2059	44.64	$ 6,180,117.84	$585,988	$46,852,551
2060	44.9	$ 6,216,113.15	$558,674	$47,411,224
2061	45.05	$ 6,236,879.68	$531,318	$47,942,542
2062	45.2	$ 6,257,646.20	$505,295	$48,447,837
2063	45.35	$ 6,278,412.73	$480,542	$48,928,380
2064	45.5	$ 6,299,179.25	$456,997	$49,385,377
2065	45.65	$ 6,319,945.78	$434,601	$49,819,978
2066	45.8	$ 6,340,712.30	$413,297	$50,233,275
2067	45.95	$ 6,361,478.83	$393,034	$50,626,309
2068	46.1	$ 6,382,245.35	$373,760	$51,000,069
2069	46.25	$ 6,403,011.88	$355,428	$51,355,497
2070	46.4	$ 6,423,778.40	$337,991	$51,693,488
Total Net Present Value				**$51,693,488**

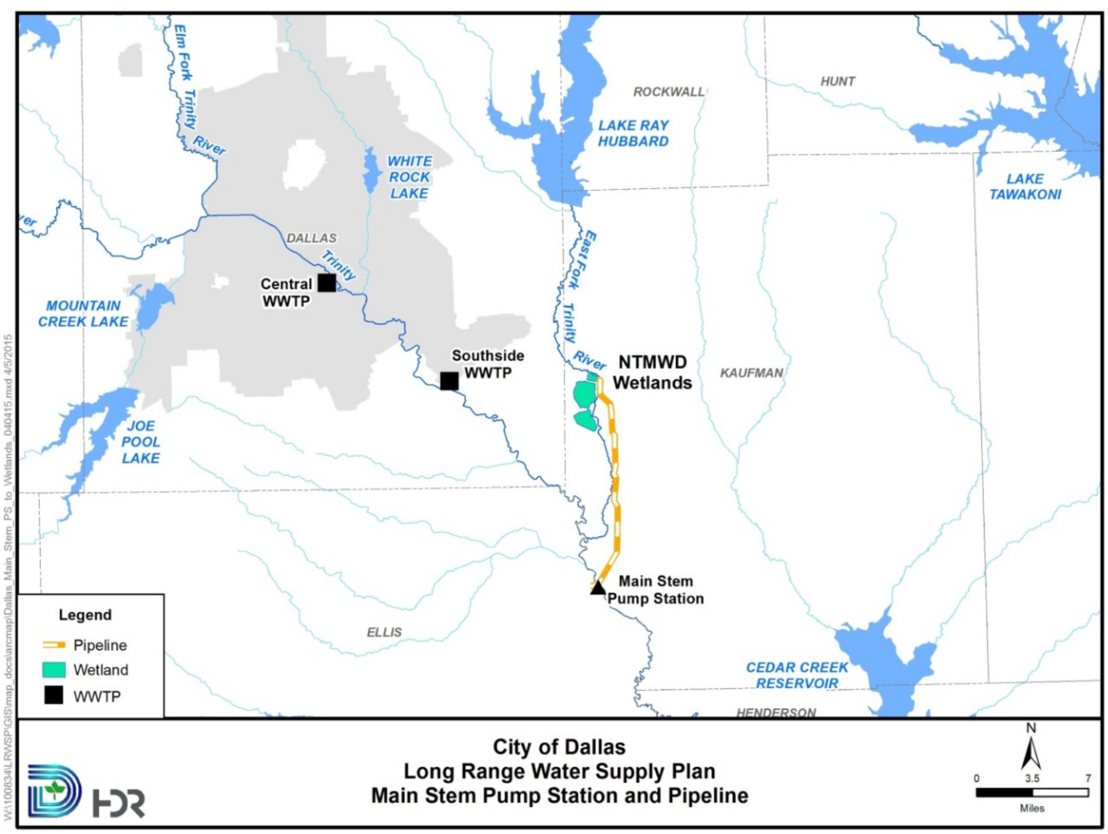
7.3 Main Stem Pump Station

In December 2008, Dallas and the North Texas Municipal Water District (NTMWD) entered into an agreement (swap 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. Under the swap agreement Dallas and NTMWD will cooperate in the construction of a pump station (Main Stem Pump Station) and transmission pipeline to deliver up to 90 MGD of return flows (from Dallas and other entities) from a location on the main stem of the Trinity River to an agreed "point of delivery" near the NTMWD wetlands located near the East Fork of the Trinity River and Hwy 175 near Seagoville. The swap agreement is currently being amended to accommodate NTMWD's need for the project to be operational by about 2017. Upon completion of the Main Stem Pump Station and pipeline, Dallas will have the right to utilize all NTMWD water discharged into Lake Ray Hubbard. Until the Main Stem Pump Station and pipeline is completed, Dallas has previously agreed to pass NTMWD's discharges from Lake Ray Hubbard.

7.3.1 Strategy Description

The project to be constructed under the swap agreement includes the construction of a Main Stem Pump Station (90 MGD) and a 72-inch diameter, 14.2 mile pipeline to transport water to the NTMWD wetlands as shown in Figure 7.3-1.

Figure 7.3-1. 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 average daily flows for this strategy for the 2020 to 2070 timeframe are shown in Table 7.3-1. By 2040 the volume of NTMWD return flows discharged into Lake Ray Hubbard is estimated to total 31.1 MGD (34,863 acft/yr). NTMWD has indicated they will attempt to acquire additional return flow quantities from Dallas and/or other entities that discharge to the Trinity River to more fully utilize the 90 MGD capacity pump station and pipeline.

Table 7.3-1. Projected Average Daily Flow Exchange under Swap Agreement [a]

Year	Average Daily Flow (MGD)
2020	23.1
2030	27.5
2040	31.1
2050	31.1
2060	31.1
2070	31.1

[a] Source Freese and Nichols memorandum dated January 30, 2014

7.3.3 Environmental Issues

Table 7.3-2 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 conditions and further detailed studies would need to be performed during permitting to address these potential concerns with the respective regulatory agencies.

Habitat

River and transmission infrastructure would be located to avoid conflicts with environmentally sensitive areas when feasible. The majority of the pipeline route occurs within areas of agricultural use including crops and pasture. Impacts to preferred habitats will be minimized by utilizing these agricultural areas which have been previously disturbed. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also potentially cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these areas.

However, 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.

Environmental Water Needs

Implementation and operation of the Main Stem Pump Station relies on the use of previously permitted return flows and will leave adequate flows in the Trinity River to meet required TCEQ environmental flow requirements.

Bays and Estuaries

Similarly, since the Main Stem Pump Station relies on the use of previously permitted return flows, it will have very limited effects on freshwater inflow to the Trinity Bay.

Threatened and Endangered Species

The species included in Table 7.3-2 represent all species federally or state listed as threatened or endangered, and federal candidate species in the county for which the project will be located. The project area includes seventeen species that meet these criteria. 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 best management practices (BMPs) during design and construction activities are 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.

Wetlands

The relatively small footprint of the project would have minimal impact to any wetlands located in the area. It is likely the project could be sited in a way to minimize these potential impacts or avoid them altogether. It is possible that some small wetlands could be located close to the riverine areas.

Table 7.3-2. Environmental Factors for Main Stem Pump Station

Environmental Factors	Comment(s)	Level of Concern
Habitat	No presence of critical or unique habitat in project area	Low
Environmental Water Needs	Minimal Impact	Low
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low impact American peregrine falcon ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, white-faced ibis ST, whooping crane FE and SE, wood stork ST, red wolf FE and SE, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, Louisiana pigtoe ST, sandbank pocketbook ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low
Wetlands	Low Impact – potential for wetlands close to river	Low

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

7.3.4 Planning Cost Estimate

Infrastructure required for the Main Stem Pump Station includes a 90 MGD intake and pump station and approximately 14.2 miles of 72-in diameter pipeline to convey flows to the NTMWD wetlands. Costs for a new channel dam to create a stable pool elevation near the intake and pump station have been included. However, it may be possible to eliminate the need for a new structure if investigations of an existing channel dam indicate its condition is acceptable or can be improved for future operations. The channel dam in question is an old dam that appears to be part of a now defunct lock and dam system that was utilized on the Trinity River in the early 1900's. Project costs for Dallas are estimated to be about 34.6% of the total project cost based on the ratio of estimated 2070 return flows from NTMWD return flows into Lake Ray Hubbard and the total capacity of the pipeline.

A summary of project and annual costs for the Main Stem Pump Station strategy is listed in Table 7.3-3. Total project costs are $75.5 million with Dallas' portion of the total project cost being $26 million. Dallas annual costs for the project assume a 30-year debt service with a 5.5 percent interest rate and delivery of 31.1 MGD are estimated to be $2,878,000 per year. The unit cost of water for this project (to Dallas) would be about $83 per acft or $0.25/1,000 gallons. After debt service, the unit cost of water (to Dallas) is decreased to $31 per acft or $0.10/1,000 gallons. Unit water costs to NTMWD would be similar to Dallas' unit costs but would need to consider the cost to purchase water from other entities.

Table 7.3-3. Cost Estimate Summary for Main Stem Pump Station

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities	DWU Portion of Costs
CAPITAL COST		
Intake, 90 MGD Pump Station and Channel Dam	$22,145,000	$7,659,000
Transmission Pipeline (14.2 miles of 72")	$32,546,000	$11,256,000
TOTAL COST OF FACILITIES	**$54,691,000**	**$18,916,000**
OTHER PROJECT COSTS		
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$17,515,000	$6,058,000
Environmental & Archaeology Studies and Mitigation	$374,000	$129,000
Land Acquisition and Surveying (91 acres)	$353,000	$122,000
Interest During Construction (4% for 1 year with a 1% ROI)	$2,553,000	$883,000
TOTAL COST OF PROJECT	**$75,486,000**	**$26,108,000**
ANNUAL COST		
Debt Service (5.5 percent, 30 years)	$5,194,000	$1,796,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$879,000	$304,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$2,249,000	$778,000
TOTAL ANNUAL COST	**$8,322,000**	**$2,878,000**
Available Project Yield (acft/yr)	**100,800**	**34,863**
Annual Cost of Water ($ per acft)	**$83**	**$83**
Annual Cost of Water ($ per 1,000 gallons)	**$0.25**	**$0.25**
Annual Cost of Water after Debt Service ($ per acft)	**$31**	**$31**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.10**	**$0.10**

7.3.5 Permitting and Implementation Issues

Dallas has a water right permit that allows for the diversion of Dallas' return flows from the Trinity River. Therefore the only significant permit required for the construction of the Main Stem Pump Station project would be a Section 404 permit from the USACE for impacts to a waterway associated with the construction of the diversion facilities and pipeline. Additionally, if it were necessary to construct a new channel dam on the Trinity River, then this structure would require a new state water rights permit and need to be considered in the Section 404 permitting process, Table 7.3-4.

Table 7.3-4. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right and Storage Permit	TCEQ	Required if a new channel dam is constructed on the Trinity River.
404	USACE	Required for construction activities in waters of the US.

7.3.6 Project Risk and Alternatives

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 Main Stem Pump Station carries with it low to no permitting risk associated with availability of return flows and required environmental flows because Dallas already has the necessary permits secured at the appropriate state agencies.

7.3.7 Agricultural and Natural Resources

Construction activities associated with the project pipeline will impact an estimated 69 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.

7.4 Main Stem Balancing Reservoir

The DWU 1975 Long Range Water Supply Plan identified a 64,000 acft balancing reservoir in Ellis County southeast of Bristol Texas as a potential delivery location for water from the proposed Tennessee Colony Reservoir. For the 2014 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 7.4-1 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.

7.4.1 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 7.4-1 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 area through a 36.5 mile transmission system. However, there are many different potential configurations of this project that require additional study to determine the best benefit for Dallas. 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 particular strategy could become a valuable asset to the Dallas water supply portfolio relying on the unique site characteristics and flexible configurations.

7.4.2 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. The water availability analysis indicated that by 2070, 109 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 7.4-1, after considering a 7 MGD loss for reservoir evaporation, the resulting 2070 firm yield is 102 MGD (114,000 acft/yr). As discussed above, there are other options for increasing the availability of this project by utilizing additional sources which would increase the project yield.

7.4.3 Environmental Issues

Table 7.4-2 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 these conditions and further study would be needed during permitting to address these potential concerns with the respective regulatory agencies.

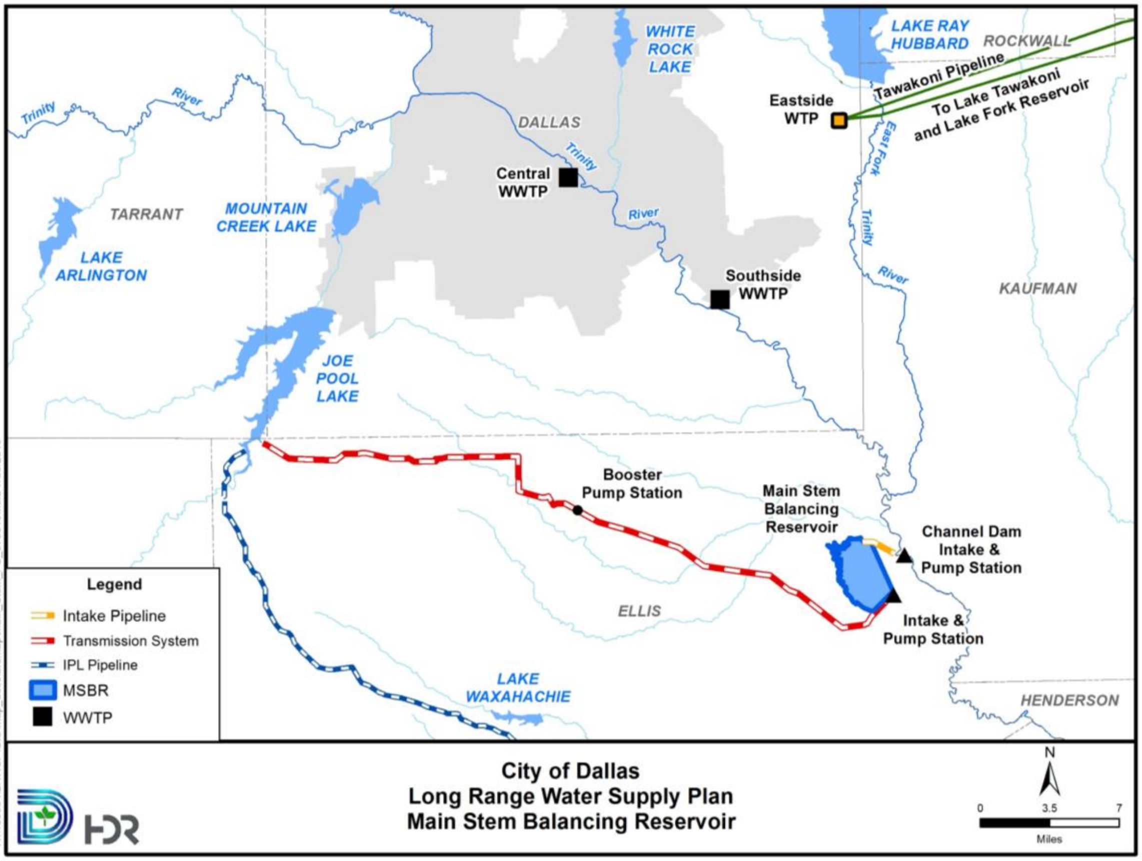
Habitat

The footprint of the reservoir occurs within an area of developed agricultural land in the Trinity River floodplain. River and transmission infrastructure would need to be located to avoid conflicts with environmentally sensitive areas where feasible. No designated critical habitat currently occurs within the project area. The pipeline route primarily crosses areas of agricultural use including crops and pasture but also includes some forested areas. Impacts to preferred habitats will 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 will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these areas.

Table 7.4-1. Summary of Available Return Flows from Dallas WWTPs

Criteria	2020	2030	2040	2050	2060	2070
Dallas Return Flows considering conservation (MGD)	164	165	176	191	206	214
Amended Instream Flow Requirement (MGD)	(74)	(74)	(74)	(74)	(74)	(74)
NTMWD Swap Agreement (MGD)	(23)	(28)	(31)	(31)	(31)	(31)
Available Return Flows (MGD)	**67**	**63**	**71**	**86**	**101**	**109**

Figure 7.4-1. Main Stem Balancing Reservoir and Pipeline



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.

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 relies on permitted return flows and will leave adequate flows in the Trinity River to meet TCEQ environmental flow standards.

Bays and Estuaries

The Main Stem Balancing Reservoir will have very limited effects on freshwater inflow to the Trinity Bay since it relies on permitted return flows and will leave adequate flows in the Trinity River to meet TCEQ environmental flow standards.

Threatened and Endangered Species

The species included in Table 7.4-2 represent all species federally or state listed as threatened or endangered, and federal candidate species in the county for which the project will be located. The project area includes sixteen species that meet these criteria. 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 and the use of best management practices (BMPs) during design and construction activities are 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.

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 US Army Corps of Engineers section 404 permitting process.

Although a number of 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.

Table 7.4-2. Environmental Factors for Main Stem Balancing Reservoir Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	No designated critical habitat in project area.	Low
Environmental Water Needs	Minimal Impact	Low
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low impact American peregrine falcon ST, bald eagle ST, golden-cheeked warbler FE and SE, interior least tern FE and SE, peregrine falcon ST, Sprague's pipit C, white-faced ibis ST, whooping crane FE and SE, wood stork ST, red wolf FE and SE, Louisiana pigtoe ST, Texas heelsplitter ST, Texas pigtoe, alligator snapping turtle ST, Texas horned lizard ST, and timber rattlesnake ST.	Low
Wetlands	No wetland vegetation areas in footprint of OCR however emergent wetlands may occur.	Low

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

7.4.4 Planning Cost Estimate

Infrastructure required for the Main Stem Balancing Reservoir include a potential channel dam on the Trinity River, a 102 MGD intake and pump station and a 72-in 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 an 84-in dia., 36.5-mile pipeline.

A summary of project and annual costs for the Main Stem Balancing Reservoir strategy with delivery to the Joe Pool area is listed in Table 7.4-3. Total project costs are $674.5

million. Annual costs for the project assume a 30-year debt service with a 5.5 percent interest rate and are estimated to be $64,887,000 per year. The unit cost of water for this project to deliver water to the Joe Pool area would be about $568 per acft or $1.74 per 1,000 gallons. After debt service, the unit cost of water is decreased to $162 per acft or $0.50 per 1,000 gallons.

Table 7.4-3. Cost Estimate Summary for Main Stem Balancing Reservoir Project

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Storage (Conservation Pool 300,000 acft, 4337 acres)	$199,834,000
102 MGD Intake, Pump Station and Channel Dam	$21,041,000
Transmission Pipeline (40 miles of 120 & 90 inch)	$163,304,000
Transmission Pump Station(s)	$44,023,000
Relocations	$5,761,000
TOTAL COST OF FACILITIES	**$433,963,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$143,722,000
Environmental & Archaeology Studies and Mitigation	$16,263,000
Land Acquisition and Surveying (4,584 acres)	$16,425,000
Interest During Construction (4% for 3 years with a 1% ROI)	$64,090,000
TOTAL COST OF PROJECT	**$674,463,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$46,407,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$3,098,000
Dam and Reservoir	$2,998,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$12,384,000
TOTAL ANNUAL COST	**$64,887,000**
Available Project Yield (acft/yr)	**114,337**
Annual Cost of Water ($ per acft)	**$568**
Annual Cost of Water ($ per 1,000 gallons)	**$1.74**
Annual Cost of Water after Debt Service ($ per acft)	**$162**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.50**

7.4.5 Permitting and Implementation Issues

The Main Stem Balancing Reservoir project would pose some permitting challenges along with the typical challenges associated with a new project (Table 7.4-4). 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 7.4-4. 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.
404	USACE	Required for construction activities in waters of the US.

7.4.6 Project Risk and Alternatives

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 Main Stem Balancing Reservoir is susceptible to performance risk associated with availability of return flows, water quality considerations and required environmental flows.

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.

Additionally, this strategy is 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.

7.4.7 Agricultural and Natural Resources

The project Balancing Reservoir site will 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 Environmental Impacts section above.

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7.5 Lake Palestine Connection

The City of Dallas and the Tarrant Regional Water District (TRWD) are partnering on the planning and development[1] of an integrated raw water transmission system to meet future water needs. The purpose of the transmission system, also known as the Integrated Pipeline (IPL), is to bring water from Lake Palestine to Dallas and 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 is referred to as the IPL Part 1 – Connection to Palestine and the second is IPL Part 2 – Connection to Bachman WTP. Section 7.5.1 presents the IPL Part 1 information and 7.5.2 presents the IPL Part 2 information.

7.5.1 IPL Part 1 – Connection to Lake Palestine – 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[2]. Dallas has contracted with TRWD for a portion of the capacity in the IPL. Dallas' portion of the 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. Figure 7.5-1 shows the overall transmission system with the various classifications of the segments, either as Dallas segments, shared Dallas / TRWD segments, or TRWD segments.

7.5.2 IPL Part 1 – Water Availability

Water supply for Dallas from the IPL will initially be from Dallas' existing contract with the UNRMWA for Lake Palestine water. This contract is for an annual quantity of 102 MGD (114,337 acft/yr). Lake Palestine is estimated to have a firm yield of 189 MGD (211,800 acft/yr) based on the 1950's drought and permitted (WAM Run 3) conditions[3]. For the 2014 LRWSP six (6) different yield scenarios were evaluated for Lake Palestine resulting from a combination of either 2020 or 2070 sediment conditions and three different drought periods 1950s, 1908, 2006. The results of this analysis showed that Dallas receives its full share of 102 MGD in all scenarios.

While Dallas' allotted capacity in the IPL will initially convey up to 150 MGD of peak day supply from Lake Palestine to the Joe Pool area, it will have, on average, an unutilized capacity of approximately 48 MGD (or about 53,800 acft/yr) which could be utilized by Dallas to deliver additional water from other strategies within the Neches River Basin.

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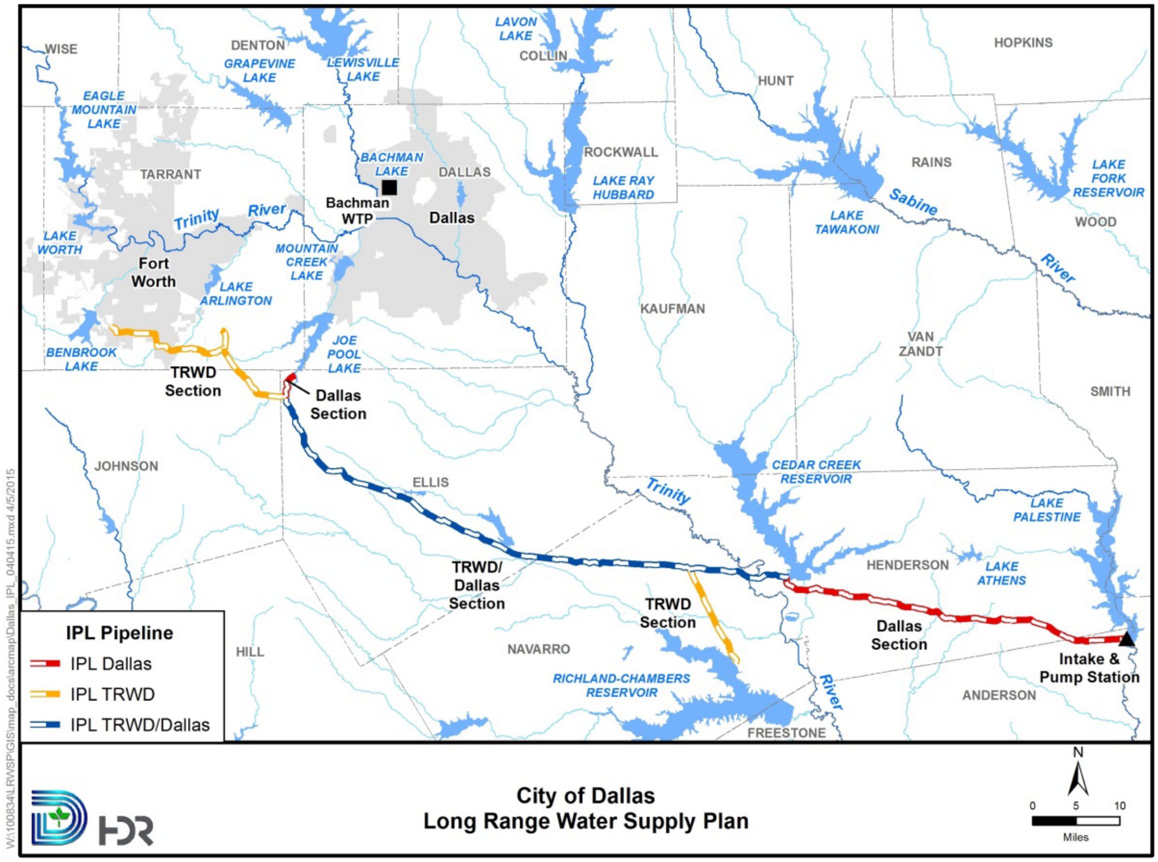
1 Tarrant Regional Water District and City of Dallas. Integrated Pipeline Project Conceptual Design Operations Study Final Report. CDM Smith, April 20, 2012.

2 http://www.iplproject.com/program-management/design-components/

3 UNRMWA. Upper Neches River Water Supply Project Feasibility Study. HDR 2014.

Figure 7.5-1. Lake Palestine Pipeline Project (IPL)



7.5.3 IPL Part 1 – Environmental Issues

Table 7.5-1 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, some coordination and permitting is already underway by TRWD for parts of the pipeline. In general, the pipeline corridor does not have any major environmental issues that can not be avoided.

Habitat

Lake intake and transmission pipeline infrastructure would be located to avoid conflicts with environmentally sensitive bottomland hardwoods and riparian areas in addition to ecologically significant stream sections. A large portion of the proposed pipeline route follows existing road right-of-ways or crosses areas of agricultural use including crops and pasture. 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 will be crossed by the pipeline corridor especially in its eastern sections. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed during construction. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these areas. However pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats. Impacts to existing habitat from project activities are anticipated to be low.

Environmental Water Needs

Implementation and operation of the IPL will have a very limited impact on daily flows in the Neches River since it will operate in accordance with the authorized water right permit for Lake Palestine.

Bays and Estuaries

Similarly, the IPL Project will have very limited effects on freshwater inflow to the Sabine Lake and Sabine Lake Estuary since it will operate in accordance with its authorized water right permit

Threatened and Endangered Species

The species included in Table 7.5-1 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 thirty species that meet these criteria. 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 numbers of listed species which potentially occur within the project area counties are not expected to present a significant challenge to the feasibility of the project.

Wetlands

Impacts to wetlands associated with this project are anticipated to be low.

7.5.4 IPL Part 1 – Planning Cost Estimate

The final design for the IPL project was initiated in July 2012. Construction is scheduled to include 3 Phases. Phase 1 includes facilities needed to fully access supplies available from Cedar Creek Reservoir and is planned to be completed in 2020. Phase 2 includes facilities needed to fully access supplies available from Richland Chambers Reservoir with bidding currently planned for 2021 and 2022. Phase 3 includes facilities needed to access Dallas supplies available from Lake Palestine with bidding currently planned to occur between 2024 and 2027.

Costs are shown in Table 7.5-2 for Dallas' portion of the project for the IPL to deliver water to the Joe Pool area based on March 2012 prices along with estimated pumping costs to deliver Dallas' Lake Palestine water (102 MGD). These costs come from the April 2012 TRWD / City of Dallas report which contains the latest opinion of probable cost. The decision was made to report the cost of this project using the more detailed cost estimate provided in the earlier report and not convert the prices using the Unified Costing Model used for other strategies in the LRWSP. The September 2013 prices are estimated to be about 3% higher than March 2012 prices according to the Engineering

News Record Construction Cost Index, a potential increase in capital costs of about $21 million. The unit cost to deliver Dallas' Lake Palestine supplies through the IPL to the Joe Pool area is $751 per acft or $2.31 per 1,000 gallons. After debt service, the unit cost would decrease to $186 per acft or $0.57 per 1,000 gallons.

Table 7.5-1. Environmental Factors for IPL Part 1 – Connection to Palestine

Environmental Factors	Comment(s)	Level of Concern
Habitat	No presence of critical or unique habitat in project area.	Low
Environmental Water Needs	Minimal Impact	Low
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low impact – American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, red-cockaded woodpecker FE and SE, white-faced ibis ST, whooping crane FE and SE, wood stork ST, golden-cheeked warbler FE and SE, black-capped vireo FE and SE, paddlefish ST, shovelnose sturgeon ST, gray wolf FE and SE, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, northern scarlet snake ST, earth fruit FT and ST, Texas fawnsfoot C and ST, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low

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

Table 7.5-2. Cost Estimate Summary for IPL Project to Deliver Lake Palestine Water to the Joe Pool Area (Dallas Portion Only)

Table units: March 2012 Dollars (April 2012 TRWD / City of Dallas report)

Item	Estimated Cost for Dallas Facilities
CAPITAL COST (Source: Latest Opinion of Probable Cost – TRWD / Dallas 2012 Study)	
Construction Costs	$678,900,000
Materials and Equipment	$49,270,000
TOTAL COST OF FACILITIES	**$728,620,000**
OTHER PROJECT COSTS	
Design Expenses	$48,720,000
Professional Services Expenses (Conceptual Design, Environmental Permitting, Geotechnical, etc.)	$95,360,000
Land Acquisition and Surveying (1,656 acres[4])	$38,040,000
Program Level Contingency	$28,210,000
TOTAL COST OF PROJECT	**$938,950,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$64,605,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$7,286,000
Pumping Energy Costs (0.08 $/kW-hr)	$14,009,000
TOTAL ANNUAL COST	**$85,900,000**
Available Project Yield (acft/yr)	**114,337**
Annual Cost of Water ($ per acft)	**$751**
Annual Cost of Water ($ per 1,000 gallons)	**$2.31**
Annual Cost of Water after Debt Service ($ per acft)	**$186**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.57**

[4] 2016 Region C Water Plan. Table P.4. 2015. http://www.regioncwater.org/Documents/2016%20Final%20Plan%20Track%20Changes/APPENDIX%20P_finaltrackChanges.pdf

7.5.5 IPL Part 1 – Permitting and Implementation Issues

The IPL Part 1 – Connection to Palestine would pose limited permitting challenges along with the typical challenges associated with a new project. A Section 404 permit from the USACE for impacts to a waterway from construction activities, such as the intake in Lake Palestine, would be needed for the construction of the diversion facilities and pipeline. These permits are summarized in Table 7.5-3.

Table 7.5-3. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
404	USACE	Required for construction activities in waters of the US.

7.5.6 IPL Part 1 – Project Risk and Alternatives

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. Part 1 of the IPL project is subject to little permitting risk as water rights are already secured and design and construction for certain phases has already commenced. The biggest risk moving forward with part 1 is likely to be risk associated with construction of the project.

7.5.7 IPL Part 1 – Agricultural and Natural Resources

The project will impact an estimated 358 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils within 5 counties along the transmission pipeline route. 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.

7.5.8 IPL Part 2 – Connection to Bachman WTP – Strategy Description

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 Bachman WTP. This is referred to as the IPL Part 2 – Connection to Bachman WTP.

Six alternative delivery options were evaluated as part of the 2014 LRWSP to deliver the IPL water from the Joe Pool Lake area to the Bachman WTP. These include the use of a combination of pipelines, reservoirs (Joe Pool and Mountain Creek Lakes) and natural stream channels (Mountain Creek and the West and Elm Forks of the Trinity River). Descriptions of these six alternatives are as follows:

- Alternative 1 – Delivery of water from the IPL directly to the Bachman Water Treatment Plant (WTP) by pipeline.
- Alternative 2 – Delivery of water from the IPL to Joe Pool Lake for diversion from Joe Pool Lake to Bachman WTP by pipeline.
- Alternative 3 – Delivery of water from the IPL to Mountain Creek Lake with water released from Joe Pool Lake for diversion from Mountain Creek to Bachman WTP by pipeline.
- Alternative 4 – Delivery of water from the IPL by pipeline directly to a new 150 MGD Southwest WTP adjacent to Joe Pool Lake.
- Alternative 5 – Delivery of water from the IPL to Joe Pool Lake for diversion from Joe Pool Lake to a new 150 MGD Southwest WTP.
- Alternative 6 – Delivery of water from the IPL through Joe Pool Lake, Mountain Creek Lake and Trinity River Channel with Delivery to Bachman WTP. Note that this option included a rerouting of a TRA discharge line (shown on the map below) to below the channel dam located on the Trinity River.

A summary of these options is presented in Table 7.5-4. This table provides a summary of capital and annual costs by strategy and provides qualitative consideration of various permitting and legal aspects of the project. A map showing all of these options is presented in Figure 7.5-2. Note that alternatives 2-5 use some part of the alternative 1 pipeline to deliver water to the Bachman WTP, only the part of the strategy that differs from alternative 1 is shown in the map using different color and style lines. Alternative 6 does not use any part of the alternative 1 pipeline and relies on the lakes and stream channels to deliver the water to Bachman WTP.

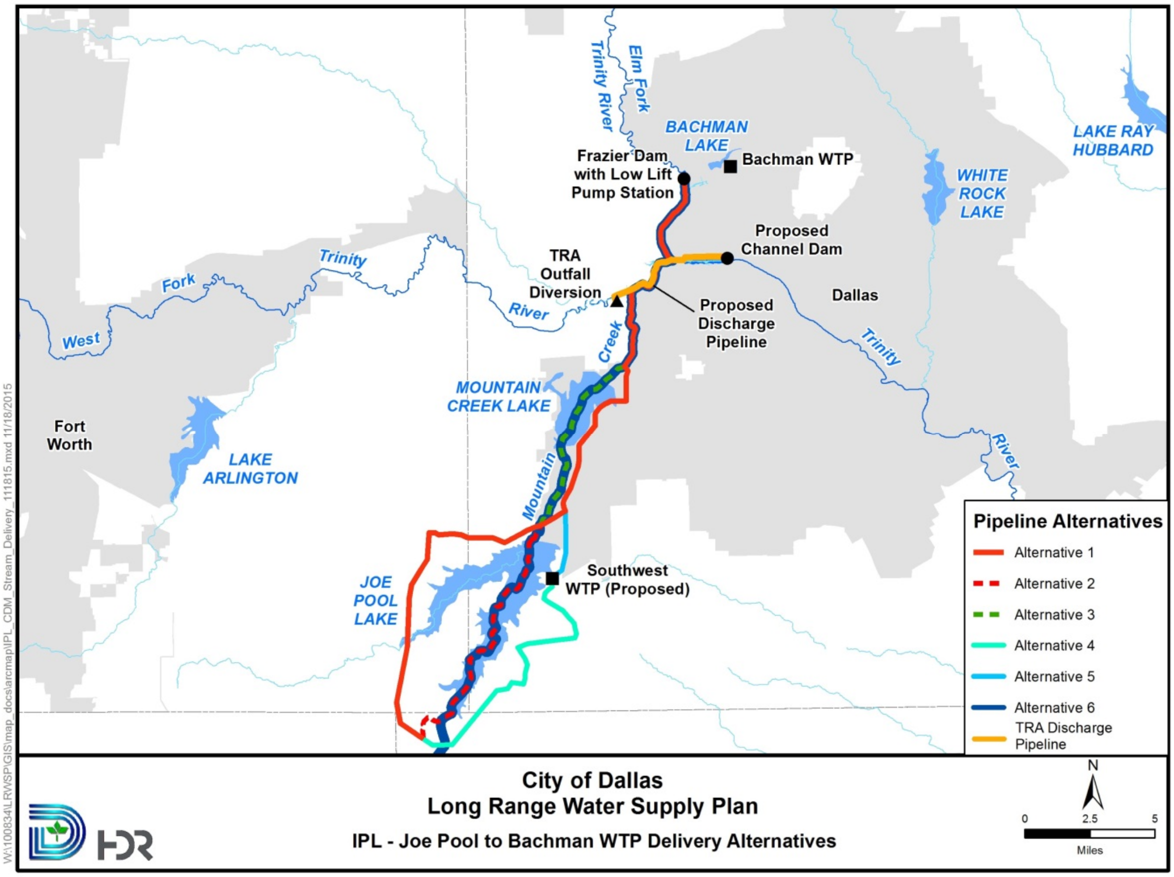
Table 7.5-4. Summary of IPL Part 2 – Joe Pool to Bachman Connection Alternatives

Alternatives	Total Capital Cost [a]	Total Annual Cost	Permitting Feasibility	Legal/Political Feasibility	Water Quality / Blending	Transmission System Flexibility
Alternative 1 – Delivery of water from the IPL directly to the Bachman WTP by pipeline	$ 1020 M	$73 M	MEDIUM	LOWER	LOWER	LOWER
Alternative 2 – Delivery of water from the IPL to Joe Pool for diversion from Joe Pool Lake to Bachman WTP by pipeline	$ 951 M	$69 M	MEDIUM	MEDIUM	MEDIUM	LOWER
Alternative 3 - Delivery of water from the IPL to Joe Pool with water released from Joe Pool for diversion from Mountain Creek to Bachman WTP by pipeline	$ 886 M	$64 M	MEDIUM	MEDIUM	HIGHER	LOWER
Alternative 4 - Delivery of water from the IPL directly by pipeline to a new 150 mgd Southwest WTP near Joe Pool Lake	$ 934 M	$83 M	MEDIUM	MUCH HIGHER	LOWER	MEDIUM
Alternative 5 - Delivery of water from the IPL to Joe Pool Lake for diversion from Joe Pool Lake to a new 150 mgd Southwest WTP	$ 832 M	$77 M	HIGHER	MUCH HIGHER	MEDIUM	MEDIUM
Alternative 6- Delivery of water from IPL through Joe Pool, Mountain Creek Lake and Trinity River Channel to Bachman WTP	$ 874 M	$63 M	HIGHER	MEDIUM	HIGHER	LOWER

Note: Low, Medium and High (or Much Higher) are qualitative rankings that were developed based on available data, previous studies, and engineering judgment.

[a] Total Capital Cost includes a 150 MGD treatment plant expansion and $371 million for distribution system improvements (Alternatives: 1, 2, 3 and 6) or a new 150 MGD treatment plant and $284 million for distribution system improvements (Alternatives: 4 and 5). These costs are not included in Table 7.5-6 for the selected alternative 1.

Figure 7.5-2. Six Delivery Alternatives for IPL Part 2 – Joe Pool to Bachman WTP



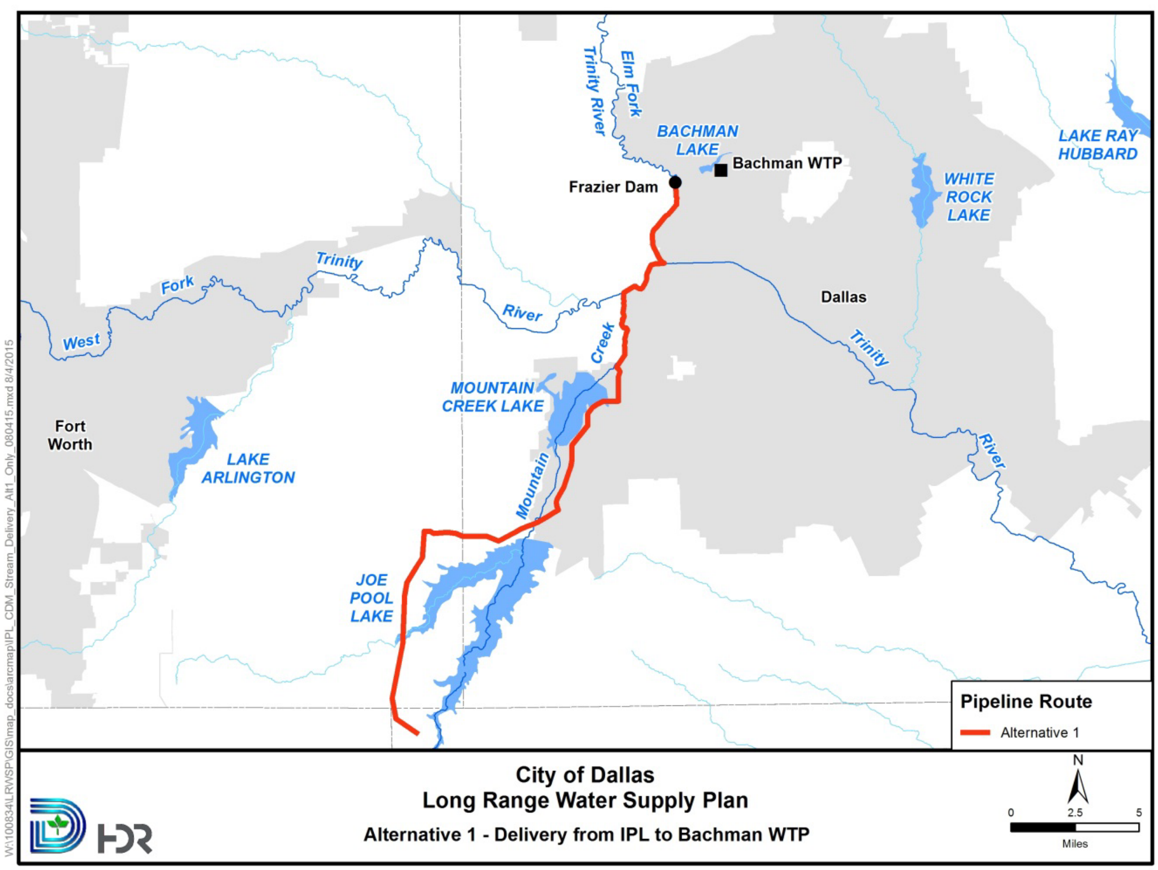
Key findings of the evaluations of these various alternatives include:

- A new Southwest WTP (alternatives 4 and 5) would incur higher annual costs than routing IPL water to the Bachman WTP, and would also incur comparatively high implementation risks. This suggests that a preferred alternative includes routing the water to the Bachman WTP, through one of four remaining alternatives.
- Of the remaining four alternatives that route IPL water to the Bachman WTP, there appears to be tradeoffs between risk and capital/annual costs. Both capital and probable annual costs decrease with increased utilization of open water bodies for conveyance, but the implementation risks increase.
- To minimize near-term costs, Alternative 6 (Trinity River Dam and maximum usage of open water bodies for conveyance) would be preferred.
- A joint study with Dallas and the owners of Joe Pool Lake and Mountain Creek reservoir is advised to determine opportunities to use those bodies for conveyance as opposed to the pipeline conveyance options.
- To minimize risk and invest in a higher likelihood of success, Alternative 1 (pipeline directly from the IPL to the Bachman Plant) would be preferred.
- Alternative 2 (routing water only through Joe Pool Lake and piping it the rest of the way to Bachman) represents a reasonable balance between expected costs and risks based on the current qualitative rankings.

The Alternative 1 delivery scenario, delivery of water from the IPL directly to the Bachman WTP by pipeline, was chosen as the recommended IPL Part 2 strategy for inclusion in the 2014 Dallas LRWSP. Even though this is the higher cost option, it carries the lowest implementation and permitting risk. The lowest implementation cost was a key consideration in selecting this strategy. As Dallas continues to implement this strategy and negotiations occur with other entities in the Joe Pool area, it is possible that this strategy will morph into one of the other alternatives to reduce the overall capital costs as the implementation risks are overcome.

As shown in Figure 7.5-3, this route delivers water from the IPL to the Bachman WTP in a closed conduit utilizing gravity and residual head from the IPL with a shallow tunnel to get through a highpoint along the route. This route parallels State Highway 360 along the west side of Joe Pool, then east on Camp Wisdom Road, heads north meandering east of Mountain Creek Lake to ultimately deliver water to the Bachman WTP. This route follows roadways for the most part to minimize impacts to developed properties but involves the highest number of highway and stream crossings. This is a gravity only alternative which minimizes the need for an additional pump station but requires the longest length of pipeline considering all alternatives: 30.5 miles of 84-inch pipeline to deliver water from IPL to Bachman WTP.

Figure 7.5-3. Recommended IPL Part 2 Delivery Scenario – Pipeline from IPL to Bachman WTP (Alternative 1)



7.5.9 IPL Part 2 – Water Availability

Part 2 of the IPL project is not subject to any additional water availability concerns not discussed in Section 7.5.1 Water Availability.

7.5.10 IPL Part 2 – Environmental Issues

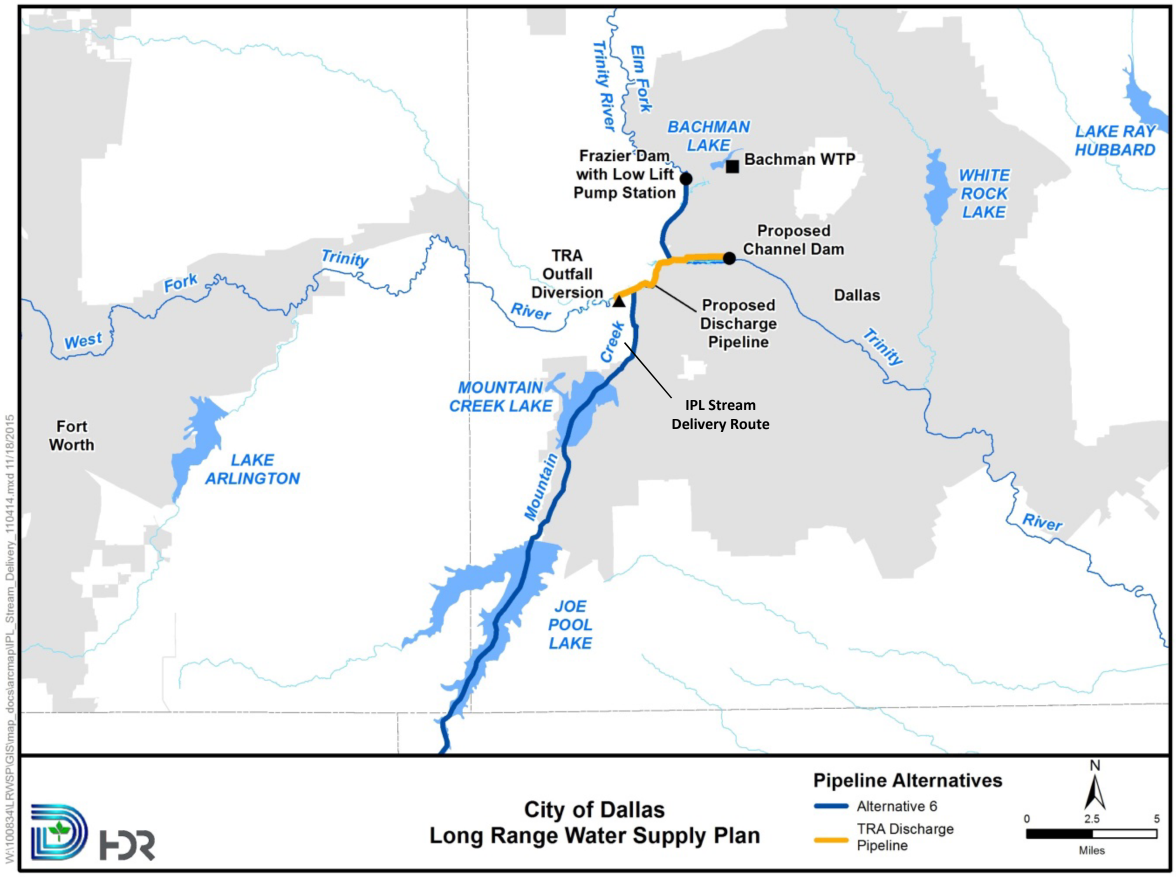
Table 7.5-5 provides a summary of known environmental factors that would need to be considered during the permitting and implementation of this project. These categories provide a general summary of conditions and further study would be needed in any feasibility or permitting efforts to address potential concerns with the respective regulatory agencies. In general, the pipeline corridor does not have any major environmental issues that can not be avoided.

Habitat

A large portion of the proposed pipeline route follows existing road right-of-ways. 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 will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. However pipelines generally have sufficient design flexibility to avoid most impacts, or significantly reduce potential impacts to geographically limited environmental habitats.

It should be noted that Alternative 6, shown in Figure 7.5-4, has additional impacts compared to the pipeline delivery options. In this alternative approximately 18 miles of stream channel along segments of the West Fork of the Trinity (2.25 miles), Elm Fork of the Trinity River (6 miles), Mountain Creek (9.75 miles), and 37 acres of bottomland hardwoods mostly in the Elm Fork portion would be inundated with the implementation of the channel dam in the Trinity River channel. Habitat found along approximately four miles of Mountain Creek would potentially benefit from the additional flows provided by the project. Impacts to existing habitat from project activities are anticipated to be medium to low.

Figure 7.5-4. Alternative Delivery of Supplies from IPL to Bachman WTP (Alternative 6)



Environmental Water Needs

Implementation and operation of the IPL Part 2 (Alternative 1) will have a no impact on daily flows in the Trinity River.

Bays and Estuaries

Similarly, the IPL Part 2 (Alternative 1) will have a no impact on effects on freshwater inflow to the any bay and estuary system.

Threatened and Endangered Species

The species included in Table 7.5-5 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 thirty species that meet these criteria. 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 best management practices (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 numbers of listed species which potentially occur within the project area counties are not expected to present a significant challenge to the feasibility of the project.

Wetlands

Only in Alternative 6 would nearly 27 acres of potential wetland vegetation area be inundated with the proposed Trinity River channel reservoir and would need to be mitigated. Although a number of wetlands occur along the proposed pipeline corridor for the other alternatives, 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.

Table 7.5-5. Environmental Factors for Lake Palestine Pipeline Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	No presence of critical or unique habitat in project area	Low
Environmental Water Needs	No Impact	None
Bays and Estuaries	No Impact	None
Threatened and Endangered Species	Low impact – American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, red-cockaded woodpecker FE and SE, white-faced ibis ST, whooping crane FE and SE, wood stork ST, golden-cheeked warbler FE and SE, black-capped vireo FE and SE, paddlefish ST, shovelnose sturgeon ST, gray wolf FE and SE, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, northern scarlet snake ST, earth fruit FT and ST, Texas fawnsfoot C and ST, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low
Wetlands	Potential for wetlands along pipeline site	Low

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

7.5.11 IPL Part 2 – Planning Cost Estimate

Costs are shown in Table 7.5-6 for the IPL Part 2 to deliver water from the IPL to the Bachman WTP (Alternative 1) based on September 2013 prices. These costs were originally developed as part of the feasibility study with TRWD[5], and were updated for the 2014 LRWSP and formatted to match TWDB Unified Costing Model to be consistent with the other strategies in this report. The unit cost to deliver Dallas' Lake Palestine supplies from the Joe Pool area to the Bachman WTP is $159 per acft or $0.49 per 1,000 gallons. After debt service, the unit cost would decrease to $12 per acft or $0.04 per 1,000 gallons. Required infrastructure includes construction of 30.5 miles of 84" pipe. The

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

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 7.5-6 for Alternative 1 do not include a 150 MGD water treatment plant expansion or additional treated water distribution system improvements as shown in Table 7.5-4.

As the project alternatives were evaluated during the LRWSP, it was assumed that a WTP expansion or new WTP would be necessary along with additional distribution system improvements. These assumptions were used to cost and rank the alternatives against each other. However, as addressed in Section 8 with a more detailed look at Dallas' infrastructure, a western subsystem WTP expansion and other distribution system improvements may be avoided until the 2050 decade. Therefore, IPL Part 2 (Alternative 1) costs are shown without the WTP expansion (estimated project cost of $405 million) and additional distribution system improvements ($371 million) since the project could be implemented as soon as the 2020 decade without these other infrastructure improvements.

Total unit cost for both parts of the IPL to deliver supplies from Lake Palestine to the Bachman WTP is $910 per acft or $2.80 per 1,000 gallons. After debt service is retired, unit costs will decrease to $198 per acft or $0.61 per 1,000 gallons.

7.5.12 IPL Part 2 – Permitting and Implementation Issues

The IPL Part 2 project could pose several permitting challenges along with the typical challenges associated with a new project. A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the pipeline. A Section 408 permit from the USACE will likely be required for construction activities near a levee. Since Alternative 1 requires a micro-tunnel underneath a USACE levee, the Section 408 permit could be a significant permitting obstacle to be overcome. These permits are summarized in Table 7.5-7.

If Alternative 1 were modified to use the bed and banks of the lakes and streams in the Joe Pool area, there are several issues associated with conveying water through Joe Pool Lake that will require resolution including the right for Dallas to store water in the lake and operational issues. 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 Joe Pool Lake.

For Dallas to store and transport water within the West and Elm Fork channels of the Trinity River, several permitting issues would need to be resolved. Approvals from the USACE would be needed to address potential impacts to levee structural integrity, flood impacts associated within the impounded water, and operation of the channel dam. Additionally a water rights permit from TCEQ would be necessary to temporarily store water in the new channel reservoir. The additional area of inundation in the Trinity River floodway inside the levee system under backwater conditions is estimated to include 235 acres.

Table 7.5-6. Cost Estimate Summary for Delivery of Palestine water from the IPL near the Joe Pool area to Bachman WTP

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Transmission Pipeline (84 in, 30.5 miles)	$138,465,000
TOTAL COST OF FACILITIES	**$138,465,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$41,540,000
Environmental & Archaeology Studies and Mitigation	$31,218,000
Land Acquisition and Surveying (552 acres)	$33,097,000
TOTAL COST OF PROJECT	**$244,320,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$16,811,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,385,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$0
TOTAL ANNUAL COST	**$18,196,000**
Available Project Yield (acft/yr)	**114,337**
Annual Cost of Water ($ per acft)	**$159**
Annual Cost of Water ($ per 1,000 gallons)	**$0.49**
Annual Cost of Water after Debt Service ($ per acft)	**$12**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.04**

Table 7.5-7. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
404	USACE	Required for construction activities in waters of the US.
408	USACE	Required for construction activities near a levee.

7.5.13 IPL Part 2 – Project Risk and Alternatives

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 IPL part 2 Project 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. It is recommended that a follow-on study to the 2014 LRWSP be performed to refine alternative 1 to develop the most feasible and cost effective option to deliver the IPL water to Bachman WTP as well as supplies from other strategies planned to be delivered to Dallas' western system.

7.5.14 IPL Part 2 – Agricultural and Natural Resources

The IPL Part 2 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. Impacts to natural resources of the state are included in the Environmental Impacts section above.

7.6 Upper Neches Project

In 2013 Dallas and the Upper Neches River Municipal Water Authority (UNRMWA) initiated the Upper Neches River Water Supply Project Feasibility Study[1] (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 an annual quantity of 114,337 acft/yr (102 MGD). 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 Upper Neches Project.

7.6.1 Strategy Description

The selected Upper Neches Project 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, 72-inch diameter pipeline 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 7.6-1).

7.6.2 Water Availability

The Upper Neches Project 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 42 MGD (47,250 acft/yr), assuming conjunctive system operations with Lake Palestine. This firm yield was calculated using the TCEQ's Neches River Basin Water Availability Model (Neches

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

WAM) which covers the 1940 to 1996 timeframe. Note that the UNRMWA study looked at several different project configurations, including options combined with off channel storage, which can provide additional yield above the recommended project configuration.

Figure 7.6-1. Upper Neches Project

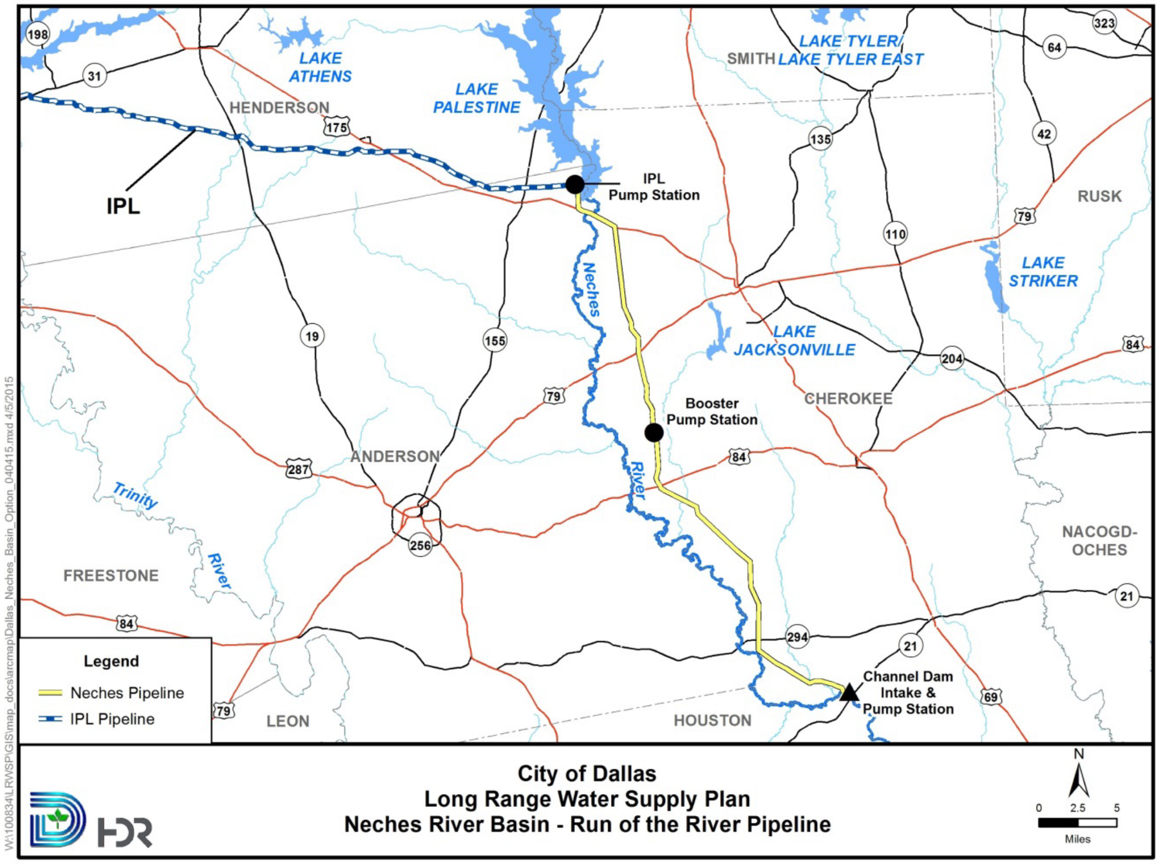


Figure 7.6-2 illustrates the percent of time that unappropriated water is available for diversion from the Neches River near SH 21 under a new appropriation. The transmission capacity of a 72-inch pipeline (~141 cfs or 91 MGD) is available about 47 percent of the time. Since the new run-of-river diversions 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 42 MGD (47,250 acft/yr). In 2010, the UNRMWA reached a settlement agreement[2] 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.

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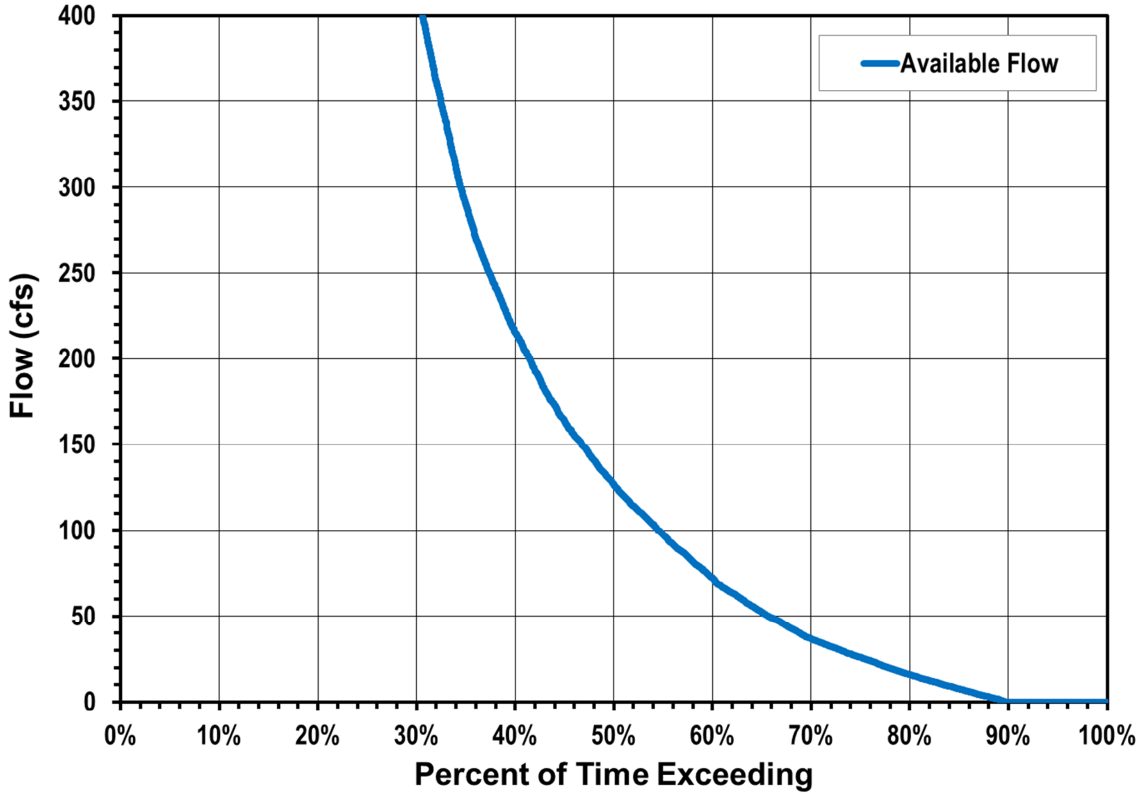
[2] UNRMWA settlement agreement with LNVA effective June 23, 2010 reference SOAH Docket No. 582-10-0159; TCEQ Docket No. 2009-0168-WR Lower Neches Valley Authority's Application for Amendment to Certificate of Adjudication No. 06-4411. Attached as Appendix N.

Figure 7.6-2. Streamflow Available for Diversion near SH 21



7.6.3 Environmental Issues

Table 7.6-1 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 conditions and further study would be needed in any feasibility or permitting effort to address these potential concerns with the respective regulatory agencies.

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 upstream of the proposed intake site. There is currently no designated critical habitat in the project area.

The proposed pipeline route will cross a Texas Parks and Wildlife Department designated ecologically significant stream segment, and areas of U.S. Fish and Wildlife Service (USFWS) Priority 1 bottomland hardwoods. A large portion of the pipeline route occurs within 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. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that will 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 pipeline route would also cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities would help to minimize potential impacts to these areas.

However, 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.

Environmental Water Needs

Implementation and operation of the Upper Neches Project will comply with TCEQ environmental flow standards and will leave adequate flows in the Neches River to sustain a healthy eco-system.

Bays and Estuaries

Similarly, the Upper Neches Project will have very limited effects on freshwater inflow to the Sabine Lake and Sabine Lake Estuary with long-term average freshwater inflows to the Sabine Lake Estuary being reduced less than 1.0 percent.

Threatened and Endangered Species

The species included in Table 7.6-1 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 twenty six species that meet these criteria. 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 best management practices (BMPs) during design and construction activities are 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.

Wetlands

Although a number of 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.

Table 7.6-1. Environmental Factors for Upper Neches Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	No presence of critical or unique habitat in project area	Low
Environmental Water Needs	Minimal Impact	Low
Bays and Estuaries	Minimal Impact	Low
Threatened and Endangered Species	Minimal impact American peregrine falcon ST, bald eagle ST, Bachman's sparrow ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, white-faced ibis ST, whooping crane FE and SE, wood stork ST, creek chubsucker ST, paddlefish ST, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, Louisiana pine snake C and ST, northern scarlet snake ST, Neches River rose-mallow FT, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST	Low
Wetlands	Minimal Impact	Low

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

7.6.4 Planning Cost Estimate

The Upper Neches Project 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 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, 72-inch diameter transmission pipeline 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 7.6-2. Total project costs are $226.8 million with energy costs for delivery of supplies through the IPL estimated to cost about $160,000 per MGD (or $143/acft-yr). Annual costs for the project assume a 30-year debt service with a 5.5 percent interest rate and are estimated to be $28,967,000 per year. The unit cost of water for this project to deliver water to the Joe Pool area (via the IPL) would be about $613 per acft or $1.88 per 1,000 gallons. After debt service, the unit cost of water is decreased to $283 per acft or $0.87 per 1,000 gallons.

Table 7.6-2. Cost Estimate Summary for Upper Neches Project

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Intake, Pump Station and Channel Dam	$26,750,000
Transmission Pipeline (42 miles of 72 and 66 inch)	$118,007,000
Transmission Pump Station	$15,206,000
TOTAL COST OF FACILITIES	**$159,963,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$50,087,000
Environmental & Archaeology Studies and Mitigation	$1,086,000
Land Acquisition and Surveying (266 acres)	$817,000
Interest During Construction (4% for 2 years with a 1% ROI)	$14,837,000
TOTAL COST OF PROJECT	**$226,790,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$15,604,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$2,174,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$4,439,000
Delivery through IPL ($160,000 per MGD)	$6,750,000
TOTAL ANNUAL COST	**$28,967,000**
Available Project Yield (acft/yr)	**47,250**
Annual Cost of Water ($ per acft)	**$613**
Annual Cost of Water ($ per 1,000 gallons)	**$1.88**
Annual Cost of Water after Debt Service ($ per acft)	**$283**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.87**

7.6.5 Permitting and Implementation Issues

The Upper Neches Project 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 waterway from construction activities would be needed for the construction of the diversion facilities and pipeline. The potential permitting requirements are shown in Table 7.6-3.

7.6.6 Project Risk and Alternatives

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 7.6-3. 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.
404	USACE	Required for construction activities in waters of the US.

7.6.7 Agricultural and Natural Resources

Construction activities associated with the project pipeline will impact an estimated 17 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 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.

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7.7 Lake Columbia

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 2011 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 76.3 MGD (85,507 acft/yr) for municipal and industrial purposes. ANRA estimates that after considering local needs, approximately 50 MGD of supply would be available to Dallas.

The reservoir would be connected to Dallas' western system via a pipeline from Lake Columbia to the proposed IPL pump station at Lake Palestine. Water would then be delivered to the Lake Joe Pool area via the IPL. As currently planned, Dallas' capacity in the IPL is 150 MGD and, after considering Dallas' Lake Palestine supply of 102 MGD, the IPL will initially have available excess capacity of about 48 MGD. Considering the potential for Dallas to manage pumping rates from both Lakes Palestine and Columbia, it is reasonable for Dallas to potentially contract for up to 50 MGD of supply from Lake Columbia. The cost split is subject to future negotiations between Dallas and ANRA. Although for purposes 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.

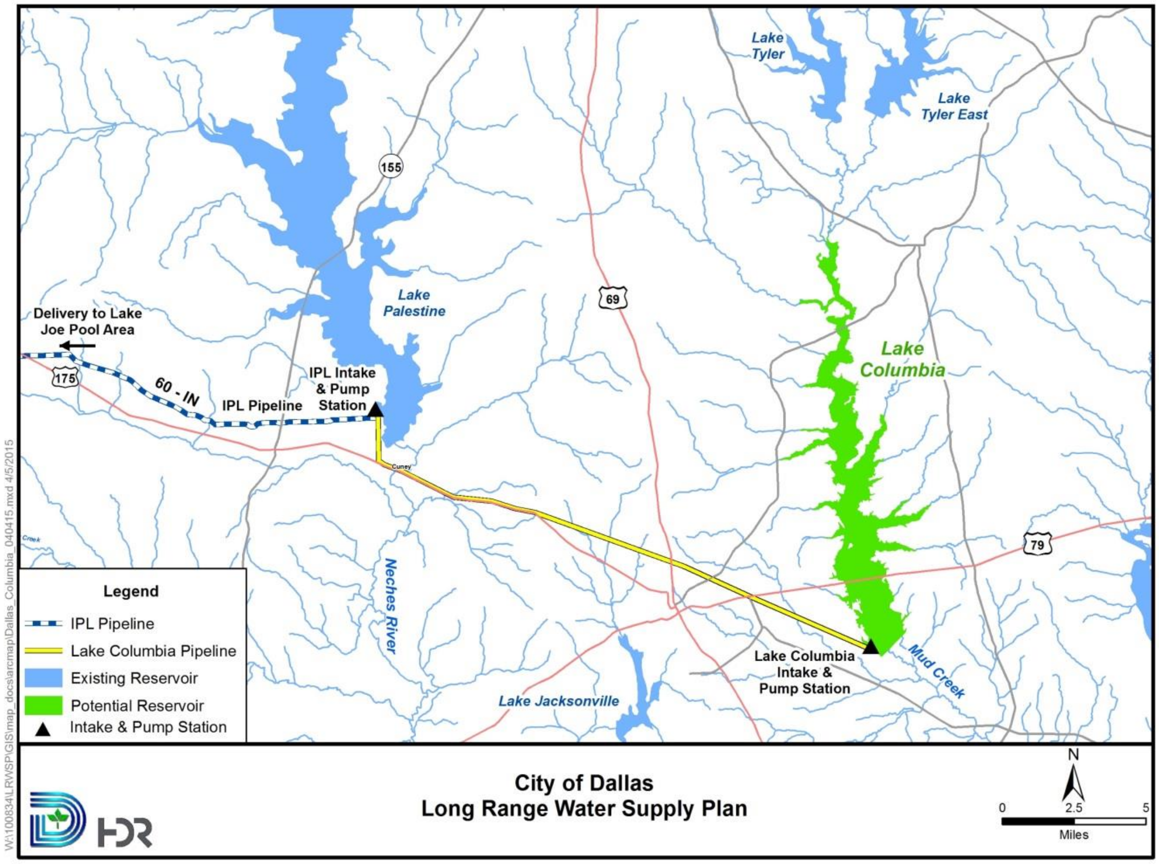
7.7.1 Strategy Description

The Lake Columbia dam site is located on Mud Creek, approximately three miles downstream of U.S. Highway 79 in Cherokee County, Texas. Figure 7.7-1 provides the location of the project and the preliminary route of the 20 mile, 42-inch diameter pipeline to the proposed 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.

7.7.2 Water Availability

A water availability analysis was performed for Lake Columbia using streamflows from Dallas' Water Supply model for the 1907 to 2007 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 90th percentile of monthly historical pass-throughs occurring in the TCEQ Water Availability Model (WAM) from 1940 to 1996. Operations of the Tyler lakes were included in the water availability analysis considering the senior priority date to Lake Columbia and other authorized diversions.

Figure 7.7-1. Lake Columbia Project



Dallas does not anticipate connecting to Lake Columbia supplies until 2070 and therefore, for purposes of this study, yields for Lake Columbia were estimated using permitted storage and 2070 conditions for net evaporation considering a +7 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 more recent 2006 drought. For Lake Columbia, the 1908, 1960's and 2006 droughts were all more severe than the 1950's drought.

Table 7.7-1 summarizes Lake Columbia firm yields for 2070 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 1908 drought proved to be the critical drought for Lake Columbia. The results show that for 2070 conditions, the firm yield of Lake Columbia does not drop below Dallas' proposed contract amount of 50 MGD. For purposes of this analysis, it was assumed that Dallas' supplies remain whole at 50 MGD with any reductions applying to the local users.

The 2011 Region I Water Plan estimates a firm yield supply of 67.5 MGD (75,700 acft/yr) for Lake Columbia which agrees closely to the 1950's firm yield calculated during this study of 67.3 MGD (75,400 acft/yr) as shown in Table 7.7-1.

Table 7.7-1. Lake Columbia Firm Yield Summary

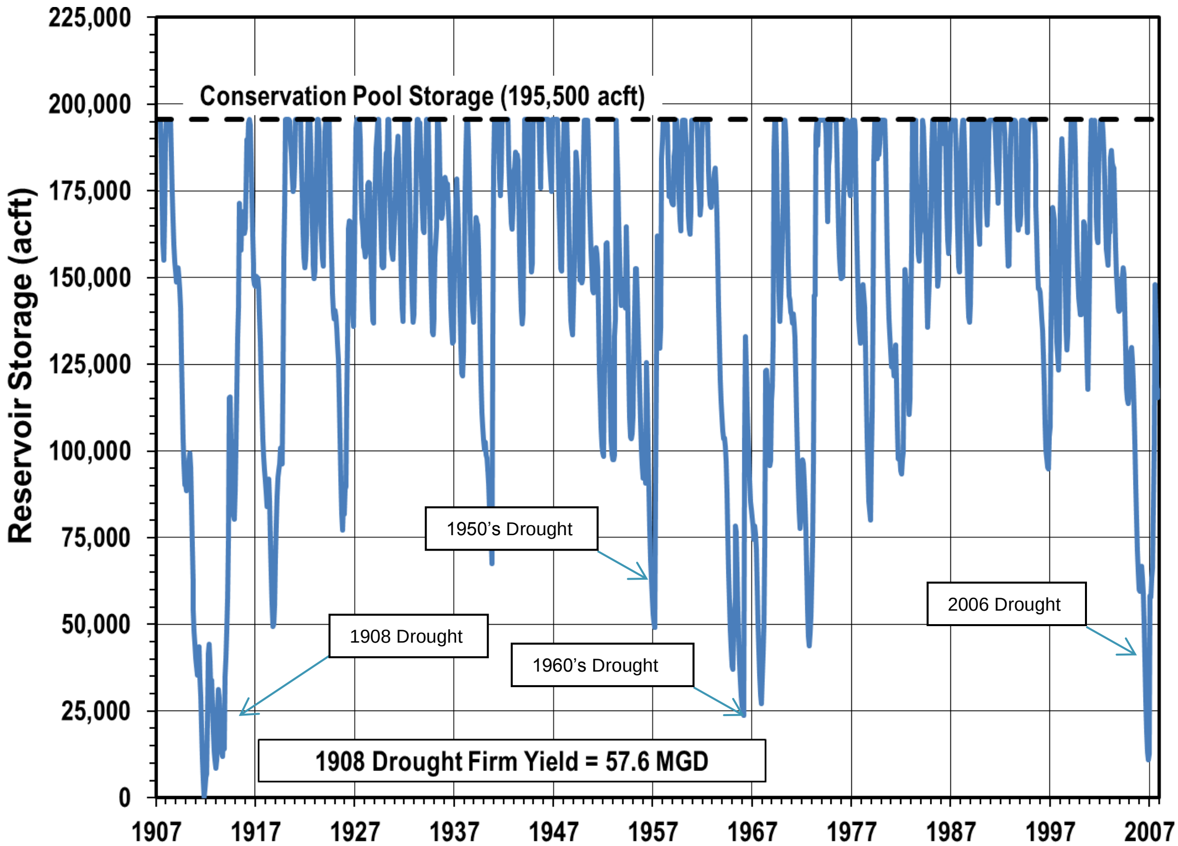
Table units: MGD

Drought	Firm Yield 2070 Conditions [a]	DWU's Percentage of 2070 Firm Yield
1908	57.6	87%
1950s	67.3	74%
1960s	63.2	79%
2006	59.7	84%

[a]2070 firm yields assume permitted storage and +7°F increase in temperature.

Figure 7.7-2 presents the Lake Columbia storage trace for 2070 conditions under the 1908 firm yield demand of 57.6 MGD (64,600 acft/yr). The storage trace shows that the 1950's drought reservoir drawdown is less severe than the 1908, 1960s and 2006 droughts.

Figure 7.7-2. Lake Columbia Storage Trace for 2070 Conditions and 1908 Drought Firm Yield Demand



Note: 2070 firm yield assume permitted storage and +7°F increase in temperature.

7.7.3 Environmental Issues

Table 7.7-2 provides a summary of known environmental factors that have previously been considered in the draft environmental impact study (EIS). These categories provide a general summary of these factors; further details pertaining to environmental issues will be available when the EIS is finalized by the U.S. Army Corps of Engineers (USACE).

Habitat

The footprint of Lake Columbia would affect approximately 5,751 acres of wetlands and 5,579 acres of bottomland hardwoods and includes a unique habitat area consisting of an herbaceous seepage bog. The proposed pipeline route will cross one Texas Parks and Wildlife Department 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. Impacts to preferred habitats will 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 will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these areas.

However, 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.

Environmental Water Needs

Implementation and operation of the Lake Columbia project will 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.

Bays and Estuaries

The Lake Columbia project will have a minimal effect on freshwater inflow to Sabine Lake and the Sabine Lake Estuary. Lake Columbia, as permitted, would have less than a 2 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.

Threatened and Endangered Species

The species included in Table 7.7-2 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 twenty nine species that meet these criteria. 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 best management practices (BMPs) during design and construction activities are anticipated to minimize potential impacts to species within the pipeline portion of 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.

Wetlands

The footprint of the project will have significant impact to wetlands located in the area. Approximately 5,751 acres of wetlands are present in the reservoir footprint that will require mitigation before for the 404 permit is granted.

Although a number of 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.

Table 7.7-2. Environmental Factors for Lake Columbia Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	Unique habitat is located in project area (herbaceous seepage bog), habitat removed from reservoir area.	High
Environmental Water Needs	Interbasin transfer could open up the permit to new TCEQ environmental flow standards.	Medium - High
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low impact American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, red-cockaded woodpecker FE and SE, Sprague's pipit C, white-faced ibis ST, wood stork ST, creek chubsucker ST, blackside darter ST, paddlefish ST, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, Rafinesque's big-eared bat ST, alligator snapping turtle ST, Louisiana pine snake C and ST, northern scarlet snake ST, Texas horned lizard ST, timber rattlesnake ST, earth fruit FT and ST, Neches River rose-mallow FT, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low
Wetlands	5,751 acres of potential wetlands and 5,579 acres of potential bottomland hardwoods	High

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

7.7.4 Planning Cost Estimate

Table 7.7-3 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.

Capital costs for the dam and relocations were extracted from the 2011 Region I RWP and updated to reflect September 2013 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 30 year debt service with 5.5% interest rate.

Table 7.7-3. Cost Estimate Summary for Lake Columbia Project (Dallas' Share)

Table units: September 2013 Dollars

Item	Estimated Cost for Dallas' Share of Facilities
CAPITAL COST	
Dallas Portion of Dam and Reservoir (70% of Total Dam and Reservoir Cost)	$33,711,000
Intake and Pump Station	$15,470,000
Transmission Pipeline (20 miles of 54 inch)	$42,531,000
Dallas Portion of Relocations (70% of Total Relocations Cost)	$68,328,000
TOTAL COST OF FACILITIES	**$160,040,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$53,888,000
Environmental & Archaeology Studies and Mitigation	$22,948,000
Land Acquisition and Surveying (8,538 acres)	$24,335,000
Interest During Construction (4% for 2 years with a 1% ROI)	$27,429,000
TOTAL COST OF PROJECT	**$288,640,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$19,860,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$812,000
Dam and Reservoir	$506,000
Pumping Energy Costs to IPL Pump Station (0.08 $/kW-hr)	$3,375,000
Delivery through IPL ($160,000 per MGD)	$7,996,000
TOTAL ANNUAL COST	**$32,549,000**
Available Project Yield (acft/yr)	**56,000**
Annual Cost of Water ($ per acft)	**$581**
Annual Cost of Water ($ per 1,000 gallons)	**$1.78**
Annual Cost of Water after Debt Service ($ per acft)	**$227**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.70**

Transmission costs include the transport of supplies to the IPL pump station at Lake Palestine via a 42-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 was 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 $32.5 million is estimated to deliver 50 MGD of supplies from Lake Columbia at a unit cost of $581 per acft or $1.78 per 1,000 gallons. After the debt service is retired, the unit cost of water would be reduced to $227 per acft or $0.70 per 1,000 gallons.

7.7.5 Permitting and Implementation Issues

In January 2010, ANRA released a draft EIS for Lake Columbia. The EIS underwent public comment in the first half of 2010. Currently, the Lake Columbia project is subject to completion of the EIS and issuance of the Section 404 permit from the U. S. Army Corps of Engineers, 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. 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 7.7-4.

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 supplies. The Construction Phase is scheduled to begin after the issuance of the Section 404 Permit from the U. S. Army Corp of Engineers.

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 76.3 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 7.7-4. 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.
404	USACE	Required for construction activities in waters of the US and will require completion of the current EIS process. Likely to include a source water assessment.

7.7.6 Project Risk and Alternatives

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 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. The challenges associated with finalizing the EIS and obtaining the Section404 permit along with the likelihood of additional environmental flow requirements being imposed as a result of the IBT amendment to the existing TCEQ permit, results in a relatively high degree of risk for a project participant located outside of the Neches River basin, such as Dallas, to participate in the project.[1,2]

7.7.7 Agricultural and Natural Resources

Lake Columbia would permanently impact an estimated 124 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 the project counties. Construction activities associated with the project pipeline would impact an additional 9 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 Environmental Impacts section above.

[1] Dallas Water Utilities. Dallas LRWSP. Lake Columbia Due Diligence, HDR 2013.
[2] Dallas Water Utilities. Dallas LRWSP. Lake Columbia Due Diligence – Water Right Permitting Issues, Webb & Webb 2013.

7.8 Direct Non-Potable Reuse

In recent years, DWU has developed plans to reclaim wastewater and reuse this water source for direct non-potable and indirect potable purposes.[1] The use of reclaimed water has become a key strategy in meeting the City's future water demands. 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 include 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.

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.

7.8.1 Strategy Description

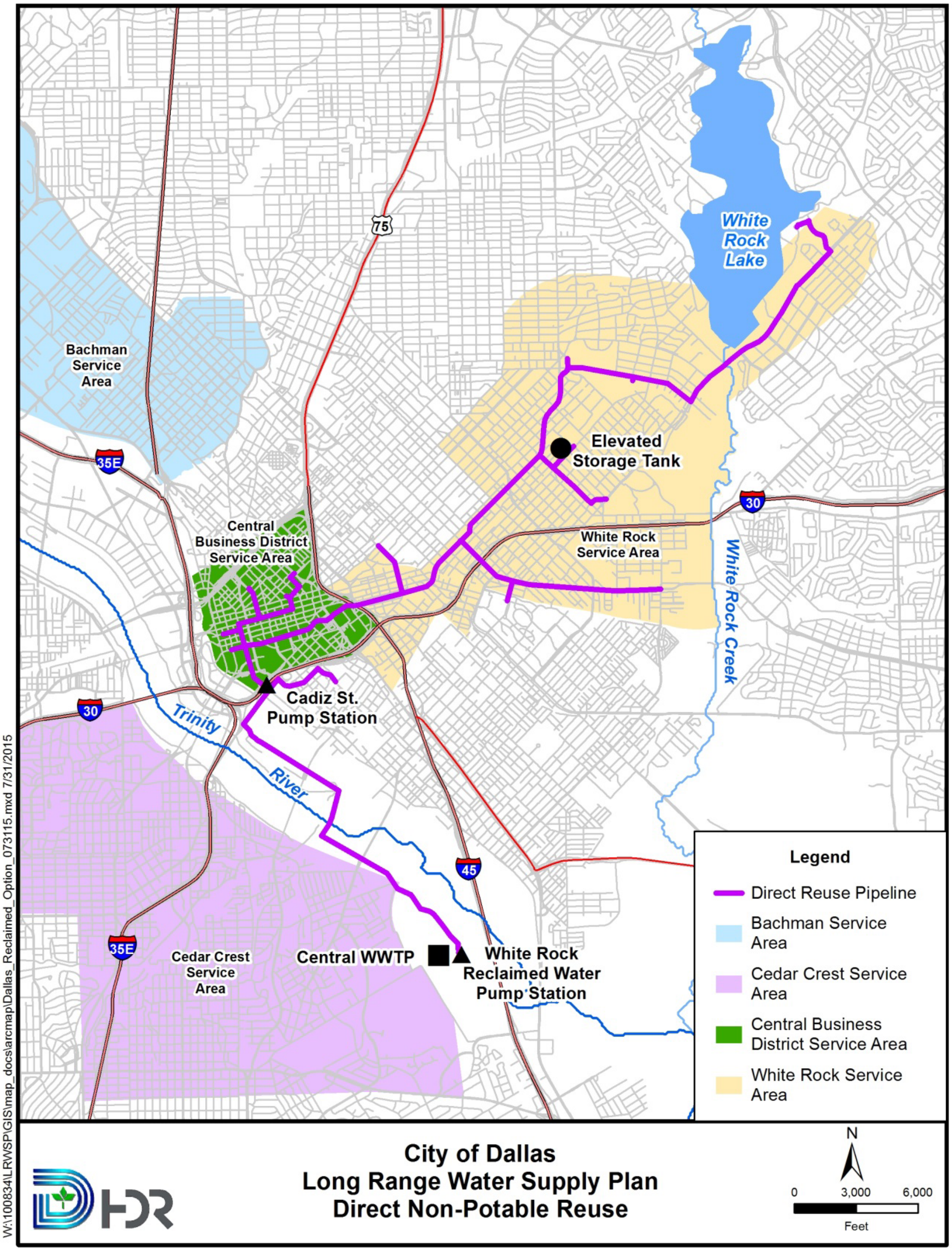
The Direct Non-potable Reuse Project includes providing reclaimed water from Dallas' Central Wastewater Treatment Plant (CWWTP) to both the Central Business District (CBD) and the White Rock Service Areas (Figure 7.8-1). The system layout maximizes potential customers and associated demands for reclaimed 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 is 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. Potential reclaimed water users in this area include the Dallas Arboretum, Lakewood Towers, Baylor Healthcare, Lakewood Country Club, Schepps, Fair Park, Randall Park, and Samuel Grand Park.

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.

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.

[1] Dallas Water Utilities. Dallas Reclaimed Water Delivery System Feasibility Study, HDR 2013

Figure 7.8-1. Strategy for Direct Non-Potable Reuse



7.8.2 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 150 MGD and the permitted peak-hour flow is 350 MGD. No water right from the state is needed for direct reuse projects.

7.8.3 Environmental Issues

Table 7.8-1 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 conditions; further detailed studies would need to be performed during permitting to address these potential concerns with the respective regulatory agencies.

Habitat

Because the project area is within a highly urbanized area it is unlikely that this project would adversely affect any listed threatened and endangered species in Dallas County. In addition there is no designated critical habitat within the vicinity of the project.

Environmental Water Needs

Implementation and operation of the Direct Non-Potable Reuse Project does note require any TCEQ water right permitting actions.

Bays and Estuaries

Similarly, since the Direct Non-Potable Reuse Project relies on the use of previously permitted return flows, it will have very limited effects on freshwater inflow to the Trinity Bay.

Threatened and Endangered Species

The species included in Table 7.8-1 represent all species federally or state listed as threatened or endangered, and federal candidate species in the county for which the project will be located. The project area includes sixteen species that meet these criteria. Due to the limited amount of disturbance associated with this project and the disturbed nature of the habitat that is contained, no impacts to any of these species are anticipated. The listed species are not expected to be a significant challenge that could render the project not feasible.

Wetlands

Possible wetlands may be located along the area of the Trinity River, however it is likely the project could be sited in a way to minimize these potential impacts or avoid them altogether.

Table 7.8-1. Environmental Factors for Non-Potable Direct Reuse

Environmental Factors	Comment(s)	Level of Concern
Habitat	No designated critical habitat in project area. Area highly urbanized.	None
Environmental Water Needs	None	None
Bays and Estuaries	None	None
Threatened and Endangered Species	Minimal impact American peregrine falcon ST, bald eagle ST, black-capped vireo FE and SE, golden-cheeked warbler FE and SE, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, white-faced ibis ST, whooping crane FE and SE, wood stork ST, Texas heelsplitter ST, Texas pigtoe ST, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST.	Low
Wetlands	No Impact	None

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

7.8.4 Planning 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 7.8-2. Total project costs are $36.6 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 $27.4 million. Dallas annual costs for the project assume a 30-year debt service with a 4 percent interest rate and delivery of 2.2 MGD are estimated to be $1,828,000 per year. Note that this interest rate is different than that used for the other Dallas strategies, because this is the rate used in the BOR study. The unit cost of water for this project would be about $731 per acft or $2.24/1,000 gallons. After debt service is retired, the unit cost of water is decreased to $102 per acft or $0.31/1,000 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 $9,145,000. This change results in a unit cost of $948/acft ($2.91/1,000 gal), a 29.7 percent increase. Costs after debt service is paid for would not be changed.

Table 7.8-2. Cost Estimate Summary for Non-Potable Reuse

Table Units: September 2013 Dollars

Item	Estimated Cost for Facilities [a]
CAPITAL COST	
Mobilization	$1,194,000
Transmission Pipeline (12 miles of 4 – 24 in dia. PVC)	$8,257,000
Transmission Pipeline (30 in dia., 54 in dia., Slipline Pipe)	$10,938,000
Transmission Pump Station	$3,446,000
Elevated Storage Tank	$1,592,000
TOTAL COST OF FACILITIES	**$25,427,000**
OTHER PROJECT COSTS	
Engineering, Bidding, Geotech, Construction Services, Survey, Bonds and Insurance, and Contingencies	$11,151,000
Bureau of Reclamation Funding (25% of total project cost)	**($9,145,000)**
TOTAL COST OF PROJECT	**$27,433,000**
ANNUAL COST	
Debt Service (4 percent, 30 years [b])	$1,572,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$203,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$53,000
TOTAL ANNUAL COST	**$1,828,000**
Available Project Yield (acft/yr)	**2,501**
Annual Cost of Water ($ per acft)	**$731**
Annual Cost of Water ($ per 1,000 gallons)	**$2.24**
Annual Cost of Water after Debt Service ($ per acft)	**$102**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.31**

[a] Costs are direct from the December 2013 DWU Feasibility Study, Table 17, page 48, and are not based on the TWDB costing tool.

[b] Debt Service and O&M Costs were obtained from Table 18, page 49, of the Dallas Reclaimed Water Delivery System – Feasibility Study, December 2013.

7.8.5 Permitting and Implementation Issues

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. R10030-001). 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 pipeline crossings associated with waters of the United States will need to be considered in the Section 404 permitting process. The potential permitting requirements are shown in Table 7.8-3.

Table 7.8-3. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
210	TCEQ	Required to reuse domestic wastewater.
404	USACE	Required for construction activities in waters of the US.

7.8.6 Project Risk and Alternatives

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.

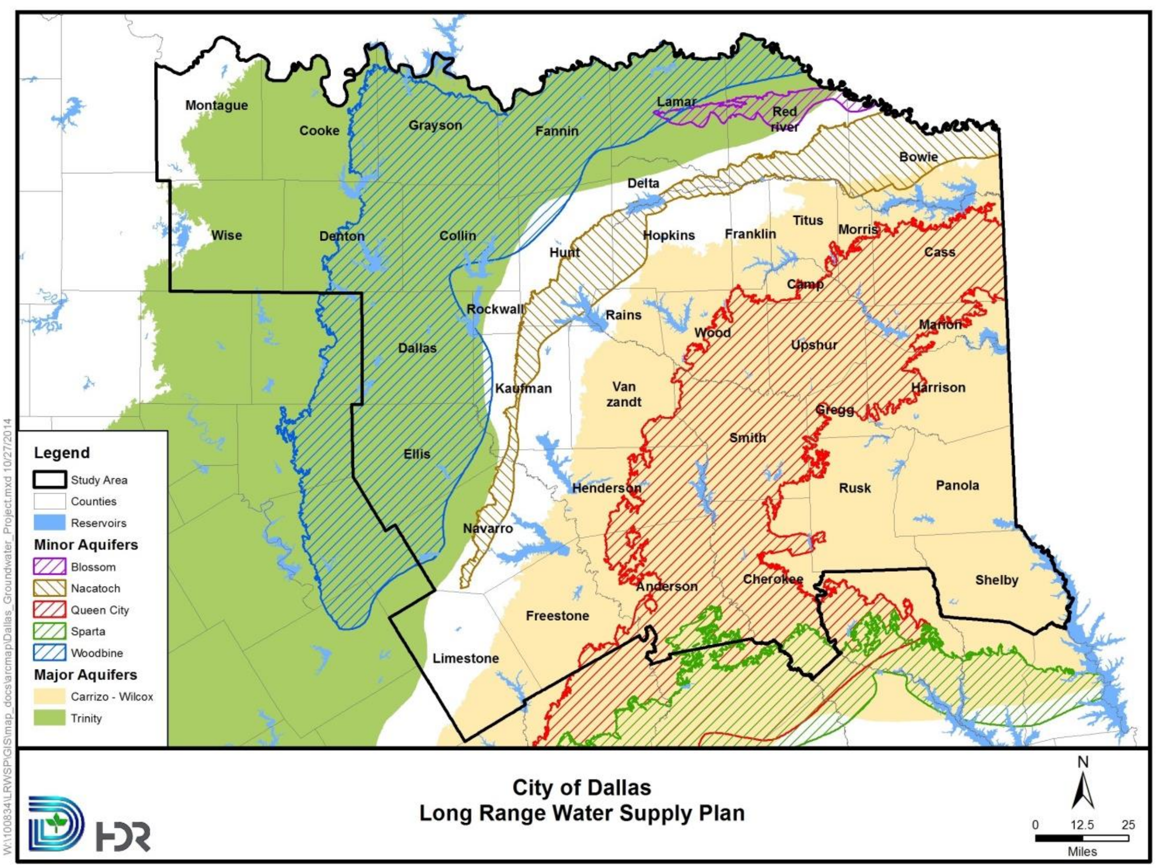
7.8.7 Agricultural and Natural Resources

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.

7.9 Carrizo-Wilcox Groundwater

Based on current and future estimates of groundwater use within Wood, Upshur and Smith counties (Figure 7.9-1) 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 92 MGD (102,930 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 2070 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.

Figure 7.9-1. Major and Minor Aquifers Evaluated



7.9.1 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. 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.

Figure 7.9-2. Carrizo-Wilcox Groundwater Project

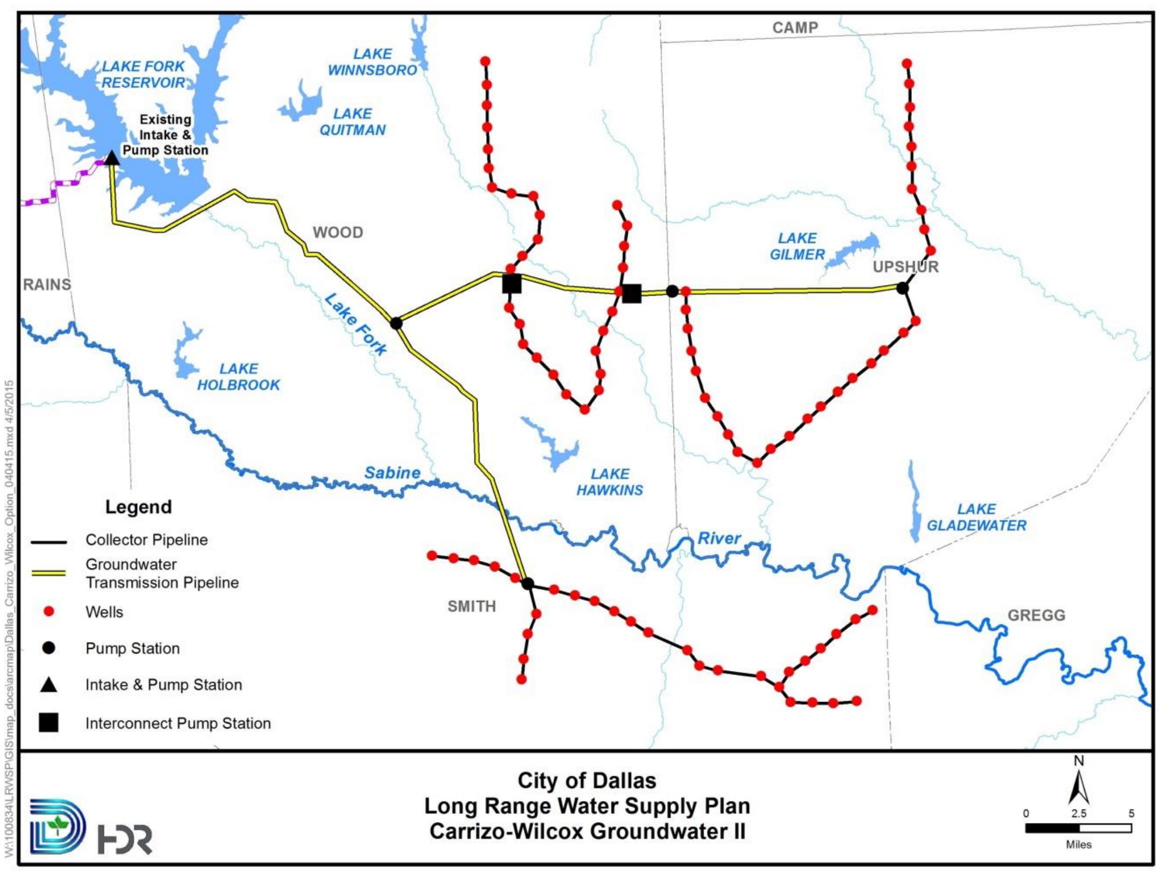


Figure 7.9-2 provides the locations of the well fields, transmission pipelines and pump stations for this strategy. The well fields have a combined maximum pumping capacity of 27 MGD (30,000 acft/yr). Groundwater from the well fields is pumped through a 58 mile transmission system to the existing intake and pump station at Lake Fork (Figure 7.9-2). 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 48 inch pipe. The Lake Fork and Tawakoni transmission pipelines will be used to convey supplies from this strategy to DWU's Eastside WTP.

7.9.2 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 7.9-1 summarizes groundwater availability for each aquifer by county and shows that up to 102,930 acft/yr (92 MGD) of groundwater is potentially available. Percentages by county and aquifer are also shown in parentheses.

Table 7.9-1. Target Counties and Available Groundwater

County	Available Queen City Groundwater (acft/yr)	Available Carrizo-Wilcox Groundwater (acft/yr)	Total Available Groundwater (acft/yr)
Smith	52,136	0	52,136 (50.7%)
Upshur	24,480	2,206	26,689 (25.9%)
Wood	9,845	14,260	24,105 (23.4%)
Totals	**86,461 (84%)**	**16,466 (16%)**	**102,930**

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 7.9-2 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.

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.

Table 7.9-2. Production for Groundwater Project

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

7.9.3 Environmental Issues

Table 7.9-3 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 conditions; further study would be included in any feasibility or permitting efforts to address these potential concerns with the respective regulatory agencies.

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 U.S. Fish and Wildlife Service (USFWS) Priority 1 and 2 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. Wooded riparian areas also commonly occur along and adjacent to stream and river areas that will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these 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 any impacts to existing habitat are anticipated to be medium to low.

Environmental Water Needs

Implementation and operation of the Groundwater Project will not have any impact to stream flows as the source of supply is groundwater.

Bays and Estuaries

Similarly, the Groundwater Project will not have any impact on freshwater inflow to the Sabine Lake and Sabine Lake Estuary.

Threatened and Endangered Species

The species included in Table 7.9-3 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 twenty six species that meet these criteria. These species would need to be considered and potentially mitigated for during project permitting and implementation. Siting of the pipelines and wells to avoid specific habitat types and the use of best management practices (BMPs) during design and construction activities are 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.

Wetlands

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

Table 7.9-3. Environmental Factors for Groundwater Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	No designated critical habitat in project area. Includes areas of bottomland hardwoods.	Low
Environmental Water Needs	None	None
Bays and Estuaries	None	None
Threatened and Endangered Species	Low impact American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, wood stork ST, creek chubsucker ST, blackside darter ST, bluehead shiner ST, paddlefish ST, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, Rafinesque's big-eared bat ST, alligator snapping turtle ST, Louisiana pine snake C and ST, northern scarlet snake ST, Texas horned lizard ST, timber rattlesnake ST, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low
Wetlands	Minimal Impact	Low

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

7.9.4 Planning Cost Estimate

The Groundwater project requires several well fields as shown in Figure 7.9-2. 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 42 inches. Two pump stations are located along the collections system lines (249 HP and 281 HP) to deliver Wood County groundwater with additional booster stations (895 HP and 164 HP) required to deliver groundwater to the Lake Fork Pump Station.

A summary of total project and annual costs for this strategy with delivery to the Eastside WTP is listed in Table 7.9-4. Total project costs are $161.1 million with energy costs for delivery of supplies through DWU's East Side Transmission system estimated at $60,000 per MGD (or $54/acft-yr). Annual costs for the project total $17,606,000 and based on a 30-year debt service with a 5.5 percent interest rate. Groundwater leases are estimated to be $1,500,000 per year or $50 per acft. The unit cost of water for this project would be about $587 per acft or $1.80 per 1,000 gallons. After debt service, the unit cost of water is decreased to $217 per acft or $0.67 per 1,000 gallons.

7.9.5 Permitting and Implementation Issues

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 land owners to construct wells and access the groundwater.

A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the transmission facilities, Table 7.9-5.

7.9.6 Project Risk and Alternatives

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 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.

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 DWU were to move forward with the Groundwater Project, that one or more groundwater districts would be created that could potentially limit the amount of groundwater that an entity like DWU would be allowed to develop and export.

Table 7.9-4. Cost Estimate Summary for Carrizo-Wilcox Groundwater Project

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Transmission Pipeline	$57,078,000
Transmission Pump Station(s) & Storage Tank(s)	$15,605,000
Well field (Wells, Pumps and Piping)	$37,212,000
TOTAL COST OF FACILITIES	**$109,895,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$35,609,000
Environmental & Archaeology Studies and Mitigation	$3,858,000
Land Acquisition and Surveying (435 acres)	$1,164,000
Interest During Construction (4% for 2 years with a 1% ROI)	$10,537,000
TOTAL COST OF PROJECT	**$161,063,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$11,082,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$1,287,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$2,130,000
Delivery through Eastside Supply Pipeline ($60,000 per MGD)	$1,607,000
Groundwater Leases (30,000 acft @ $50/acft)	$1,500,000
TOTAL ANNUAL COST	**$17,606,000**
Available Project Yield (acft/yr)	**30,000**
Annual Cost of Water ($ per acft)	**$587**
Annual Cost of Water ($ per 1,000 gallons)	**$1.80**
Annual Cost of Water after Debt Service ($ per acft)	**$217**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.67**

Table 7.9-5. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
404	USACE	Required for construction activities in waters of the US.

7.9.7 Agricultural and Natural Resources

Construction activities associated with the project transmission pipeline will impact an estimated 85 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.

7.9.8 References

Broom, M. E., Ground-Water Resources of Wood County, Texas, prepared by the U.S. Geological Survey (USGS) Texas in cooperation with the Texas Water Development Board, TWDB Report 79, August 1968.

Broom, M. E., Ground-Water Resources of Gregg and Upshur Counties, prepared by the U.S. Geological Survey (USGS) Texas in cooperation with the Texas Water Development Board, TWDB Report 101, October 1969.

Dillard, Joe W., Availability and Quality of Ground Water in Smith County, Texas, Texas Water Commission in cooperation with the Tyler Chamber of Commerce, May 1963.

Intera Incorporated (Intera), Groundwater Availability Models for the Queen City and Sparta Aquifers, October 2004.

Intera Incorporated (Intera) and Parsons, Final Report, Groundwater Availability Model for the Carrizo-Wilcox, prepared for the Texas Water Development Board, January 31, 2003.

7.10 Sabine Conjunctive Use Project

The Sabine conjunctive use project combines groundwater supplies from the Groundwater project as described in Section 7.9 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 Dallas 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.

7.10.1 Strategy Description

The two projects selected for the combined operations are the Smith 1B 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 7.9. The Smith 1B 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.

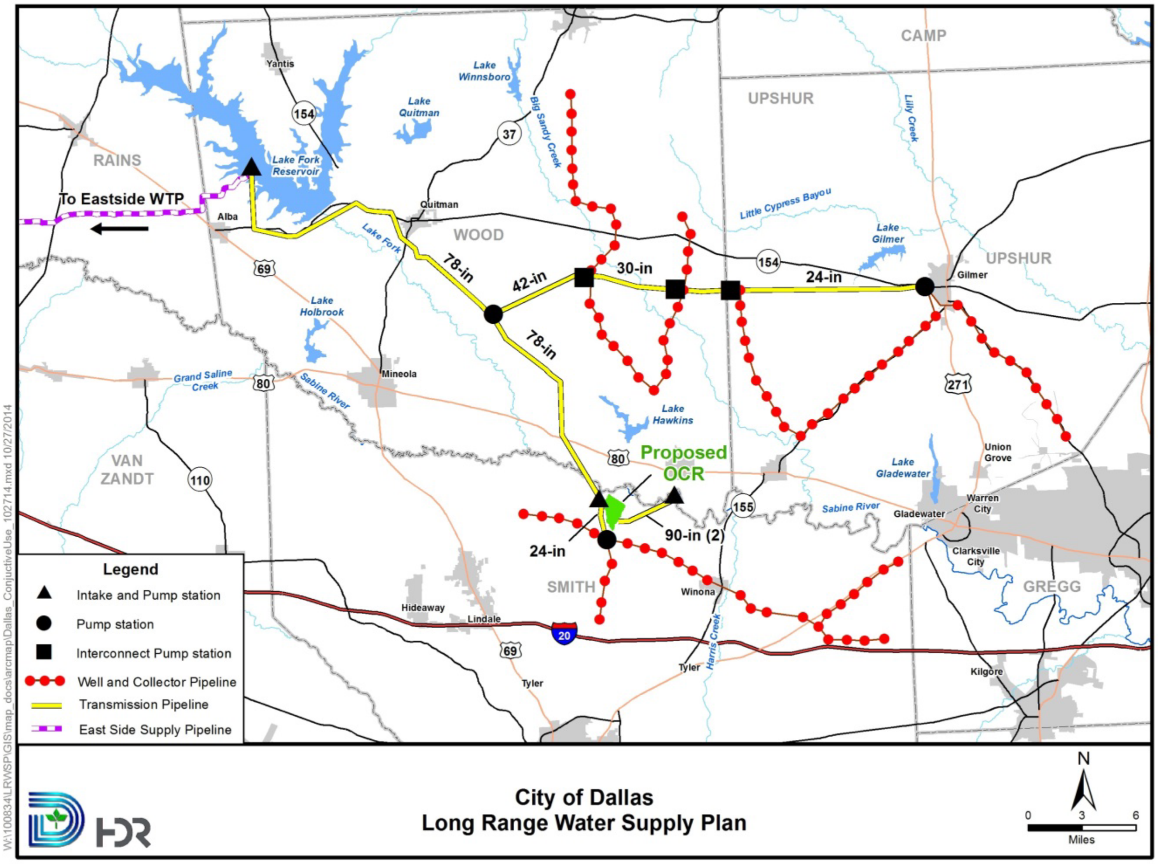
The OCR stores streamflow diverted from the Sabine River using a 400 cfs (258 MGD) intake and pump station and two 90-inch diameter short-distance transmission pipelines. Water stored in the OCR is subsequently diverted at a maximum rate of 93 MGD to the Lake Fork pump station through a 78-inch diameter 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 by relying on available stream flows from the Sabine River for diversion into the reservoir.

The groundwater component includes 90 wells that pump water from the Queen City and Carrizo-Wilcox aquifers in Wood, Upshur, and Smith counties for delivery to the Lake Fork pump station. Figure 7.10-1 shows the locations of the OCR, well fields, transmission pipelines, and pipeline diameters, and pump stations for this strategy.

The groundwater well field has a maximum pumping capacity of 40 MGD (44,500 acft/yr). The location of the most eastern arm of the well field in Upshur County was adjusted from the well field layout presented in Section 7.9 because aquifer characteristics southeast of the City of Gilmer are more suitable for pumping to meet peaking demands needed for conjunctive use operations as opposed to a constant pumping rate required for the stand alone constant supply Groundwater project.

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 7.10-1 for subsequent delivery to DWU’s Eastside WTP via the Eastside pipeline.

Figure 7.10-1. Sabine Conjunctive Use Project



7.10.2 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 7.10-2 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 7.10-3 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 7.10-4 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

Figure 7.10-2. Off-Channel Reservoir Storage Trace for 1940 to 1998 Simulation Period

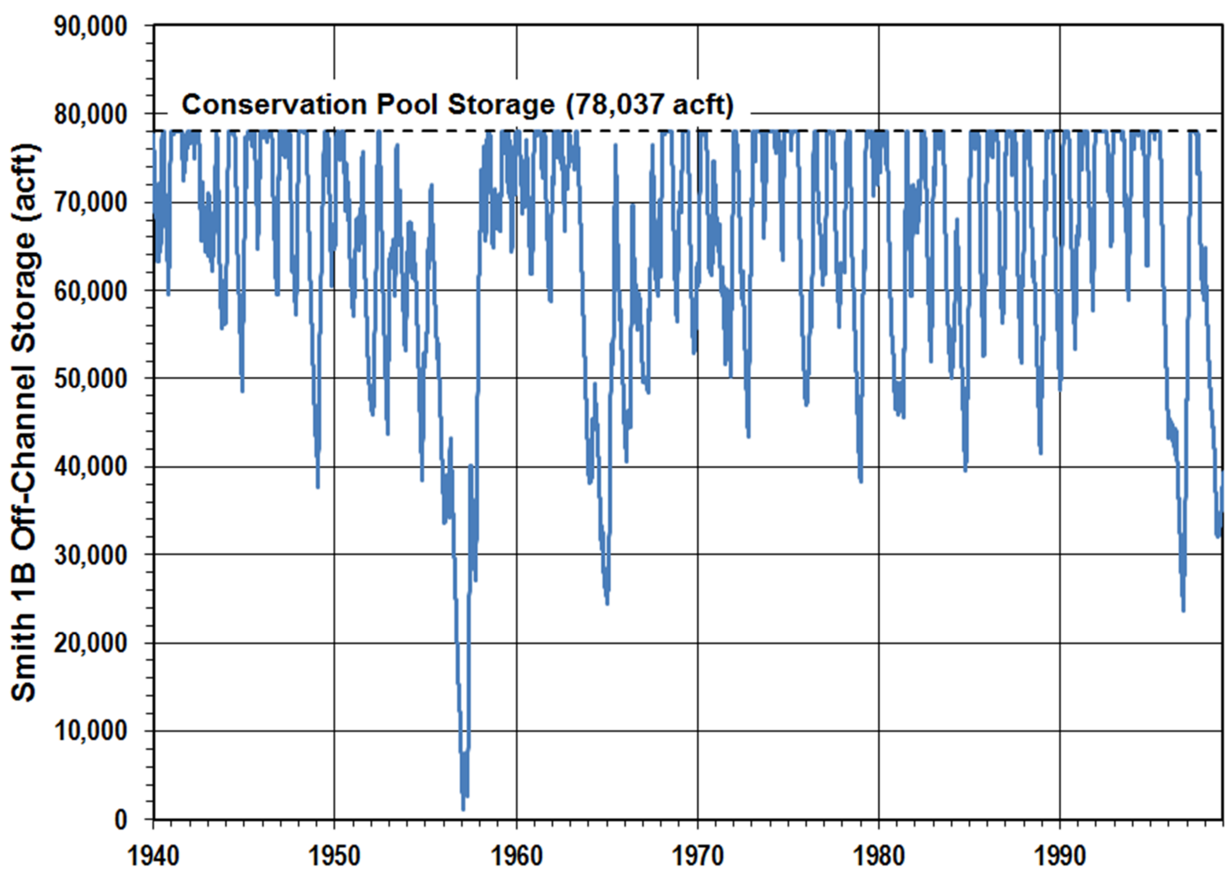


Figure 7.10-3. Sabine Conjunctive Use Supply Sources (1940 to 1998)

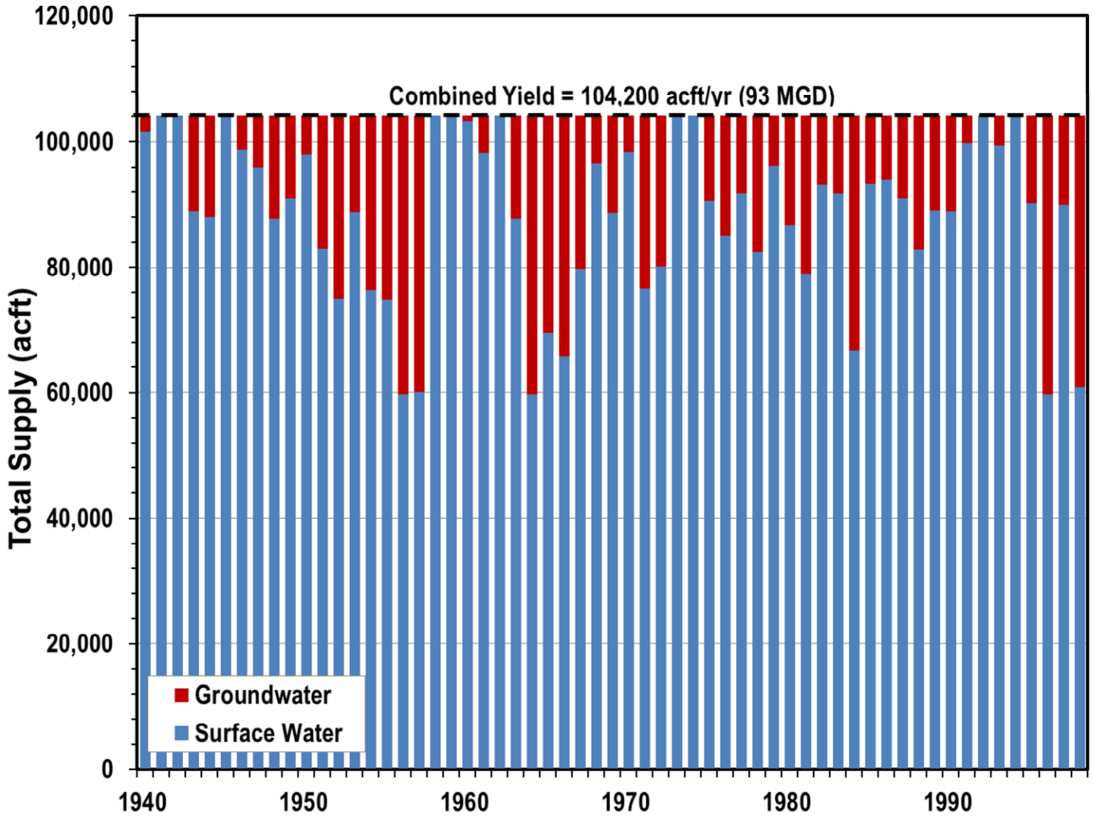
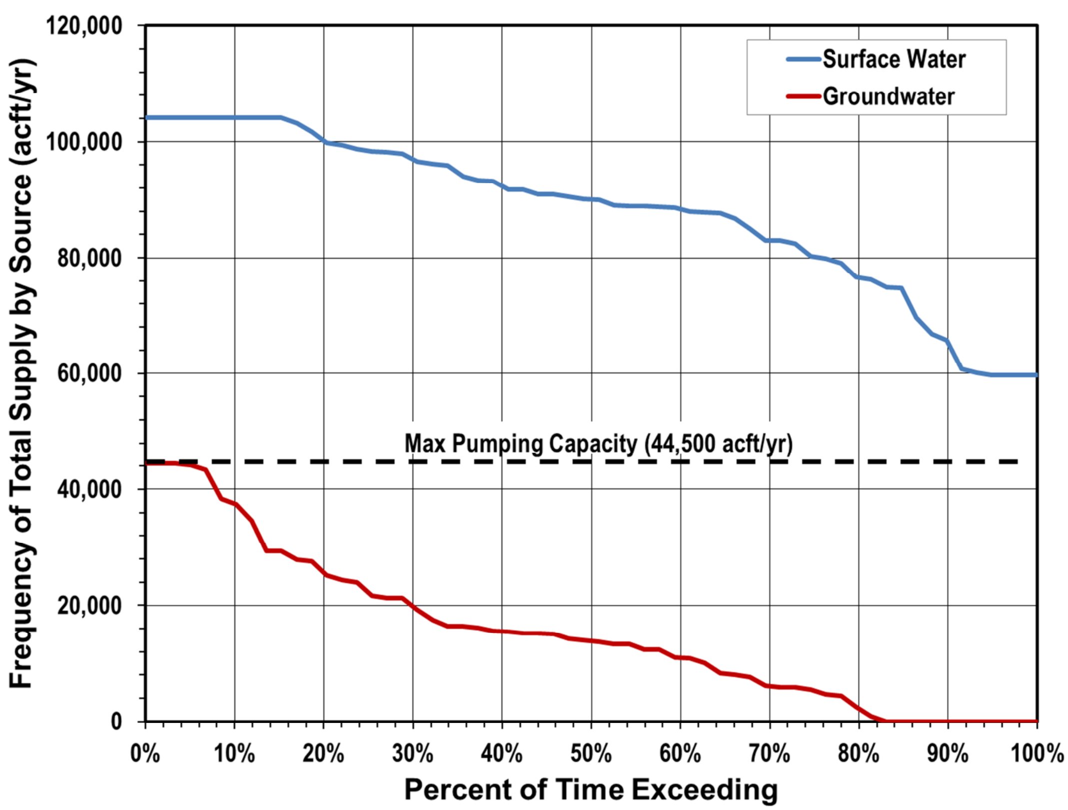


Figure 7.10-4. Frequency of Use for Sabine Conjunctive Use Supply Sources (1940 to 1998)



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 described in Section 7.9). In 10 years of the simulation or about 17 percent of the time, the entire supply comes from surface water.

7.10.3 Environmental Issues

Table 7.10-1 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.

Habitat

The well fields, OCR and transmission infrastructure would be located to avoid conflicts with environmentally sensitive areas when feasible. 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 Texas Parks and Wildlife Department designated ecologically significant stream segment, and areas of U.S. Fish and Wildlife Service (USFWS) Priority 1 and 2 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 could 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 will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed by construction activities. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these 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 any impacts to existing habitat are anticipated to be medium to low.

Environmental Water Needs

Implementation and operation of the well fields will not have any impact on stream flows as the source of supply is groundwater. While Sabine River diversions will periodically reduce Sabine River streamflows, this new diversion will need to be permitted by TCEQ and therefore will comply with applicable TCEQ environmental flow standards.

Bays and Estuaries

As a result of the distance and the large intervening drainage area between the diversion site and Sabine Lake and the Sabine Lake Estuary, the conjunctive use project will have very limited effects on freshwater inflows.

Threatened and Endangered Species

The species included in Table 7.10-1 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 twenty six species that meet these criteria. 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 best management practices (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 are not expected to present a significant challenge to the feasibility of the project.

Wetlands

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

Approximately 77 acres of potential wetlands occur within the OCR footprint and would be inundated by the project. Coordination with the USACE will be required during the Section 404 permitting process and mitigation would be necessary for these areas.

Table 7.10-1. Environmental Factors for Upper Neches Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	Medium to Low Impact	Low
Environmental Water Needs	Minimal Impact	Low
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low impact American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, wood stork ST, creek chubsucker ST, blackside darter ST, bluehead shiner ST, paddlefish ST, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, Rafinesque's big-eared bat ST, alligator snapping turtle ST, Louisiana pine snake C and ST, northern scarlet snake ST, Texas horned lizard ST, timber rattlesnake ST, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, and Texas pigtoe ST.	Low
Wetlands	Medium to Low Impact	Low

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

7.10.4 Planning Cost Estimate

Project costs are summarized in Table 7.10-3. The assumed cost of leasing groundwater is $50 per acft. The conjunctive use strategy is estimated to provide 93 MGD (104,200 acft/yr) at a unit cost of $740/acft or $2.27 per 1,000 gallons. If the OCR and groundwater were operated as separate, stand alone projects, they would provide 87 MGD (97,200 acft/yr) at a unit cost of $812/acft or $72/acft (or 10 percent) more than the unit cost of the conjunctive use strategy. 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. This results in an increase in total water supply of 7 percent and a reduction in unit costs of about 10 percent when comparing the stand-alone projects to the conjunctive use project.

7.10.5 Permitting and Implementation Issues

Implementation of the Sabine River diversion and OCR will require permits from both state and federal agencies as shown in Table 7.10-2. 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 land owners to construct wells and access the groundwater, which is accounted for in the cost estimate.

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 7.10-2. 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.
404	USACE	Required for construction activities in waters of the US.

7.10.6 Project Risk and Alternatives

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 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.

Table 7.10-3. Cost Estimate Summary for Sabine Conjunctive Use Project

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Reservoir	$284,471,000
Intake, Pump Station and Channel Dam	$48,835,000
Transmission Pipelines	$140,992,000
Transmission Pump Stations and Storage Tanks	$19,648,000
Well Fields (Wells, Pumps, and Piping)	$37,212,000
TOTAL COST OF FACILITIES	**$531,158,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$178,856,000
Environmental & Archaeology Studies and Mitigation	$6,466,000
Land Acquisition and Surveying (1,239 acres)	$3,714,000
Interest During Construction (4% for 2 years with a 1% ROI)	$75,621,000
TOTAL COST OF PROJECT	**$795,815,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$54,756,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$3,423,000
Dam and Reservoir	$4,267,000
Pumping Energy Costs (0.08 $/kW-hr)	$8,308,000
Delivery through Eastside Pipeline ($160,000 per MGD)	$5,582,000
Groundwater Leasing (@ $50/acft)	$783,000
TOTAL ANNUAL COST	**$77,119,000**
Available Project Yield (acft/yr)	**104,200**
Annual Cost of Water ($ per acft)	**$740**
Annual Cost of Water ($ per 1,000 gallons)	**$2.27**
Annual Cost of Water after Debt Service ($ per acft)	**$215**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.66**

7.10.7 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.

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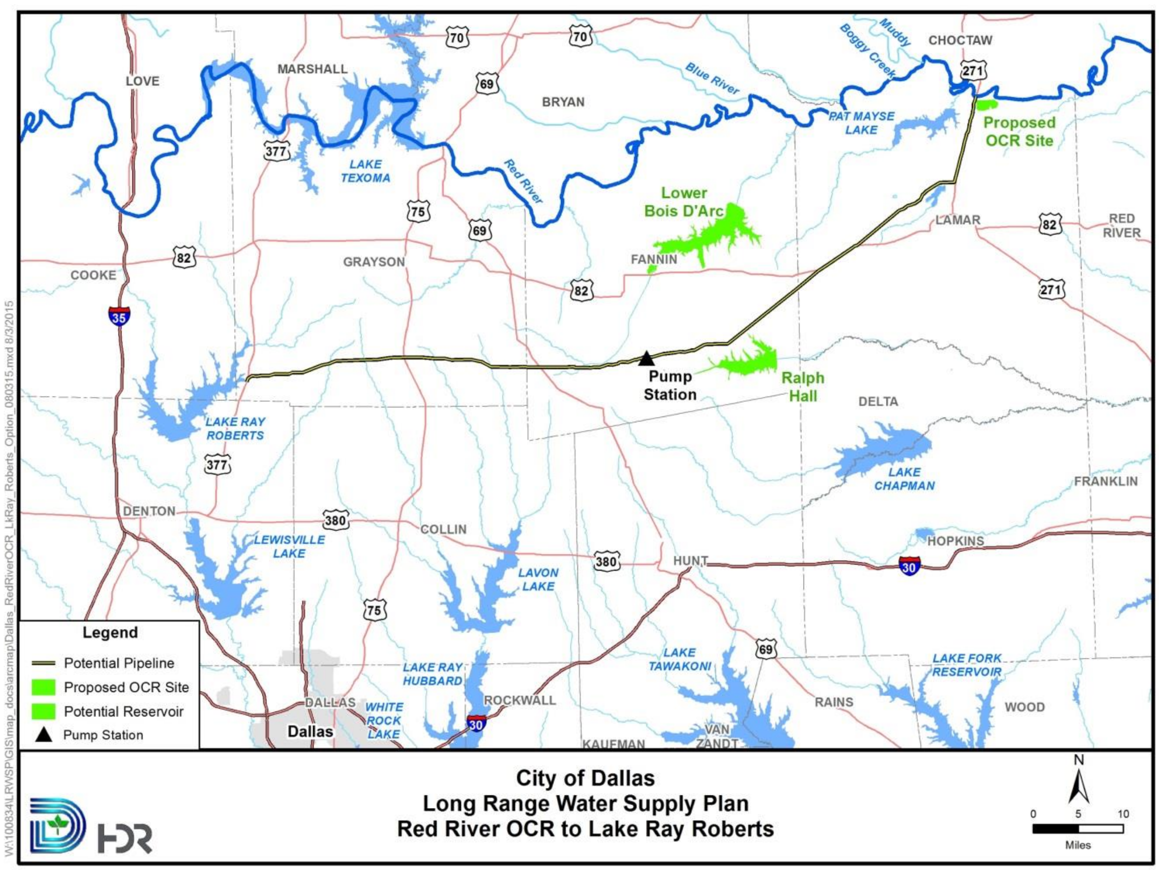
7.11 Red River Off-Channel Reservoir

The Red River Off-Channel Reservoir (OCR) 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.

7.11.1 Strategy Description

The Red River OCR project includes a 162 MGD (250 cfs) intake and pump station on the Red River at Arthur City, TX immediately downstream of the Highway 271 Bridge (Figure 7.11-1). 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 7.11-1. Red River Off-Channel Reservoir Project



Diversions from the Red River would be pumped approximately 2 miles via an 84-in 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 129 MGD (200 cfs) intake and pump station and would transport, on average, about 102 MGD (114,000 acft/yr) via an 84-in 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 7.11-2 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 determined 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.

7.11.2 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 7.11-3 provides the annual available flow calculated in the TCEQ WAM for the 1948 to 1998 period of record. The WAM estimates that, on average, almost 5 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 7.11-4 shows frequency curves of both 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. In other words the actual water available is higher when evaluated outside the confines of the TCEQ Red River WAM. Figure 7.11-5 shows the same frequency for lower flows at the site. The figures reveal that the 129 MGD (250 cfs) river diversion would be able to be exercised approximately 94% of the time without consideration of days with poor water quality.

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.

Figure 7.11-2. Red River Off-Channel Reservoir Layout

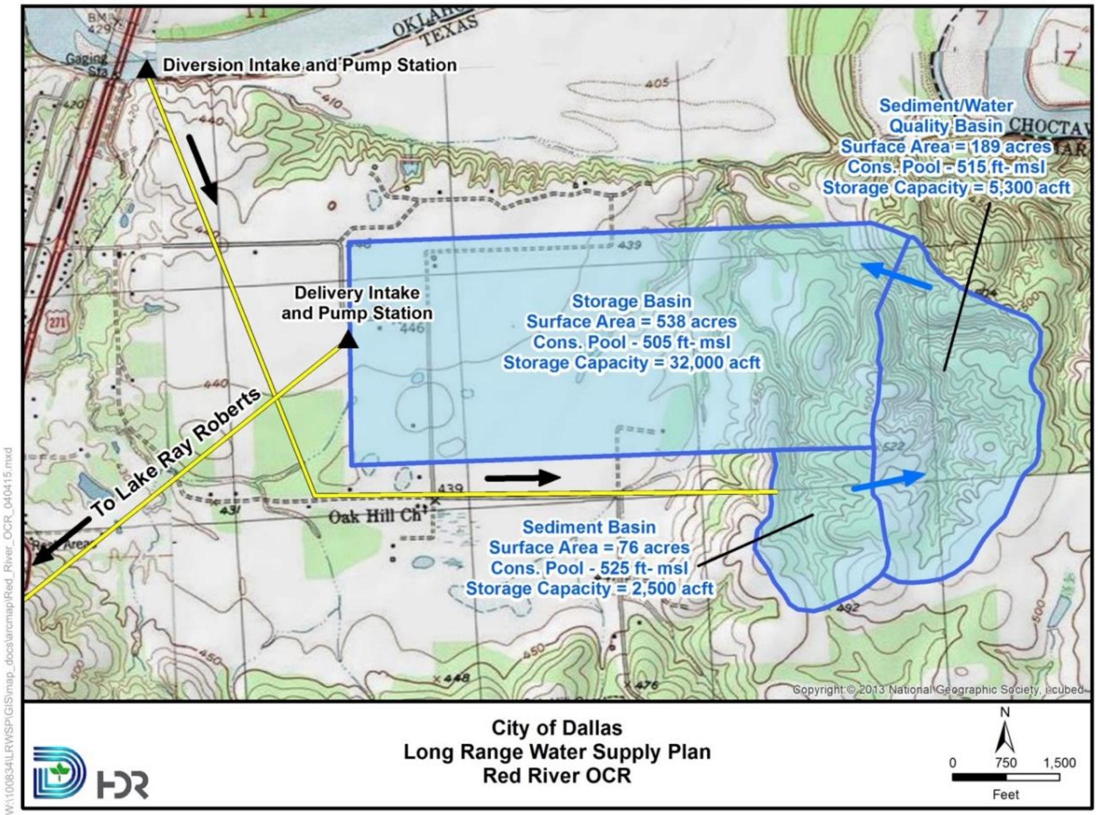


Figure 7.11-3. TCEQ WAM Annual Available Streamflow for Texas Entities at Arthur City Diversion Site

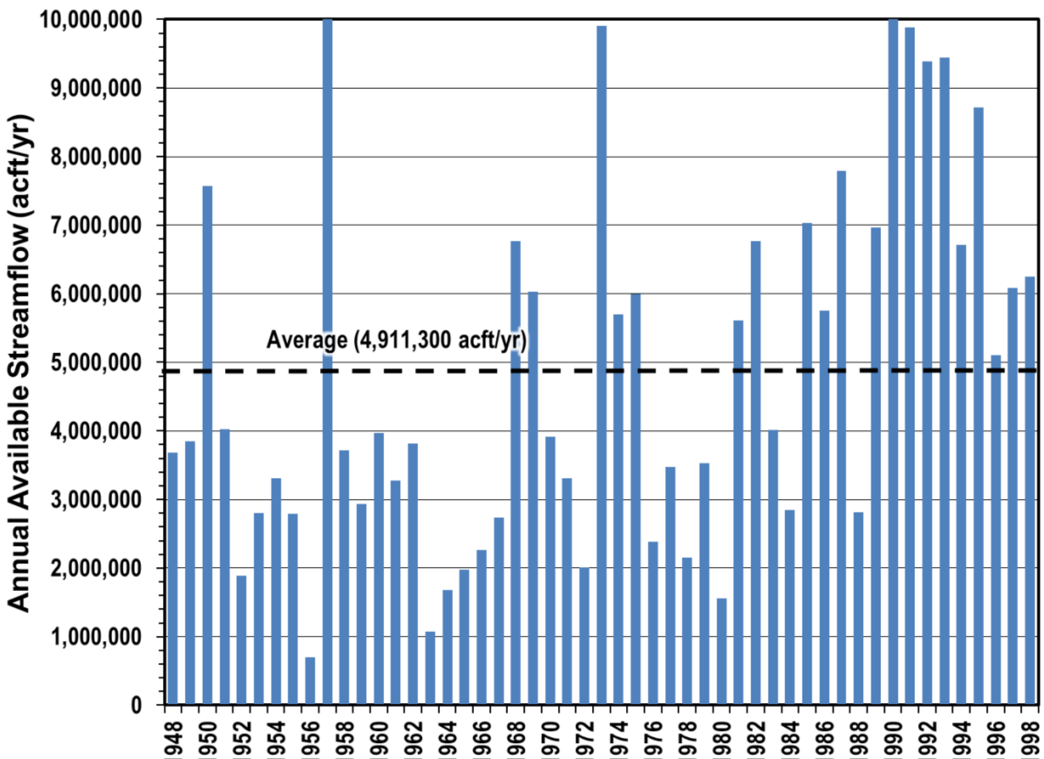


Figure 7.11-4. Frequency of Daily Available Streamflow at Arthur City Diversion Site

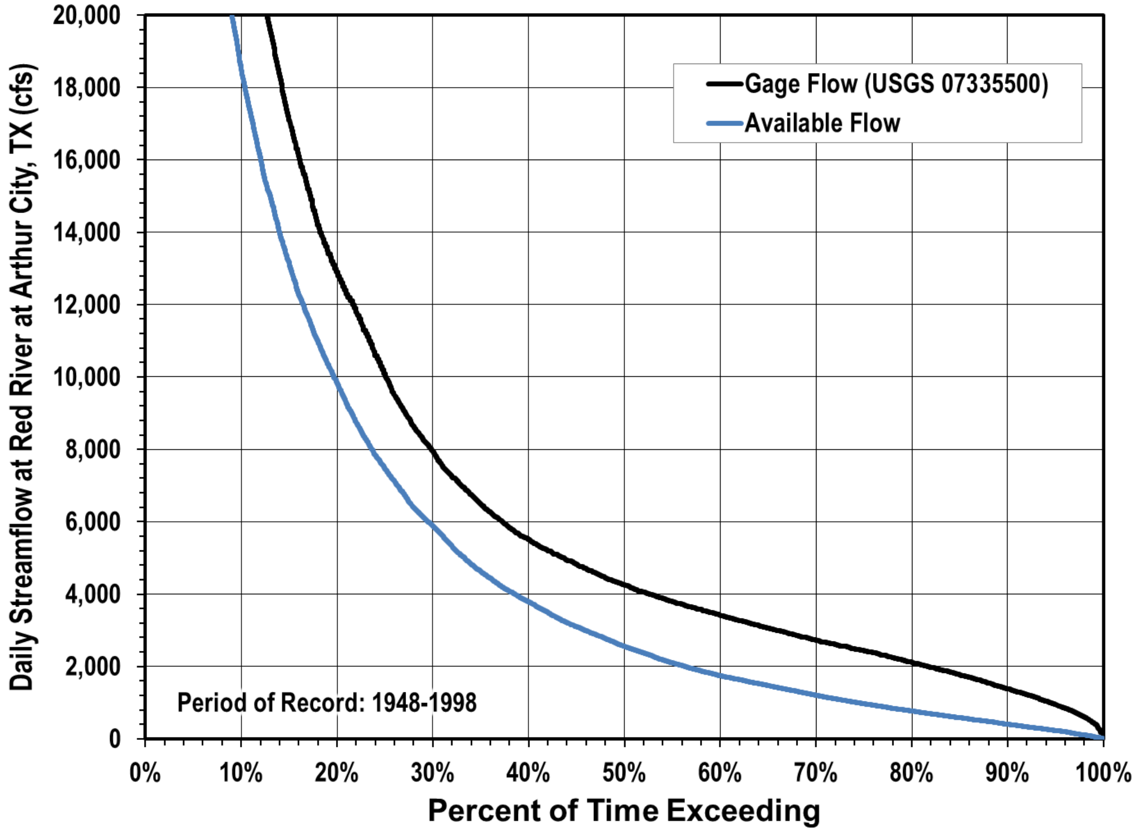


Figure 7.11-5. Frequency of Daily Available Low Flows at Arthur City Diversion Site

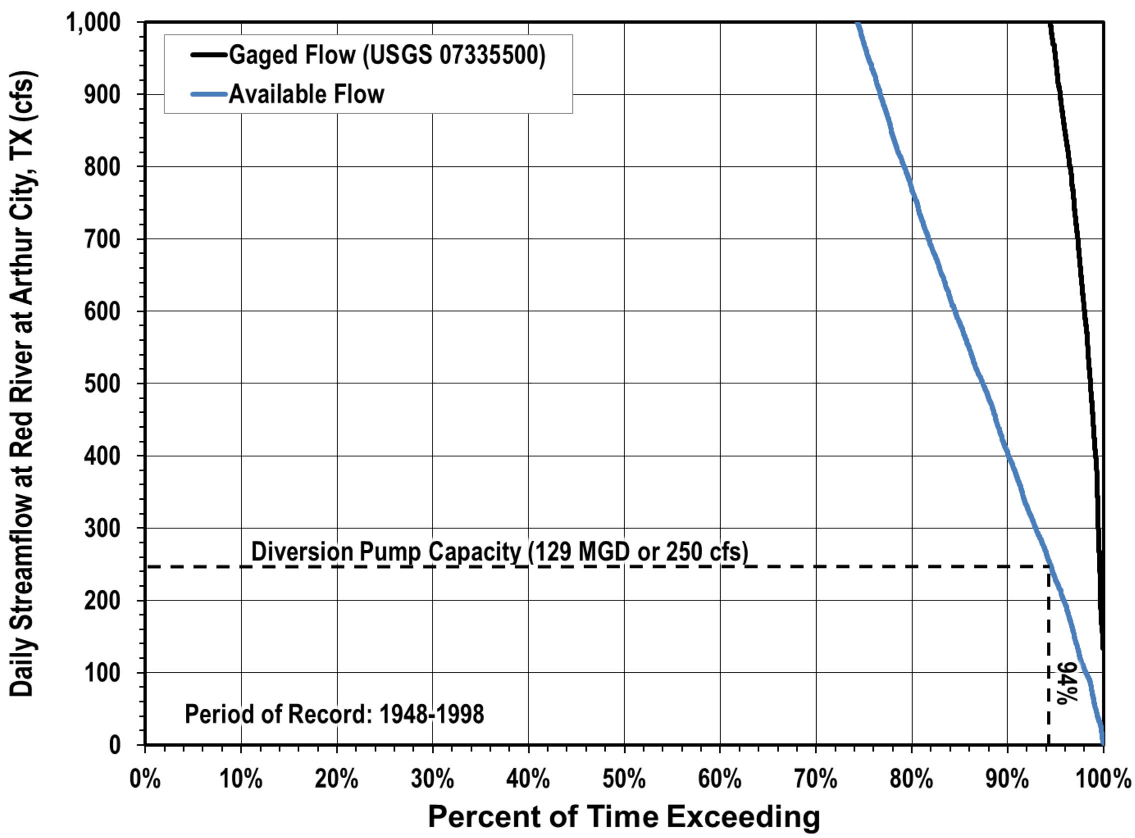


Figure 7.11-6 and Figure 7.11-7 provide time series and frequency plots of storage of the 32,000 acft OCR. For the yield analysis, the storage capacities of the two smaller OCR sedimentation basins were not considered. The storage frequency indicates that the 32,000 acft OCR would remain full almost 90 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 were performed using higher diversion rates and indicate that an expansion of the facilities would be able to provide upwards of 535 MGD (600,000 acft/yr) of regional supply with a high level of reliability. 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.

Figure 7.11-6. Daily Storage of Red River OCR

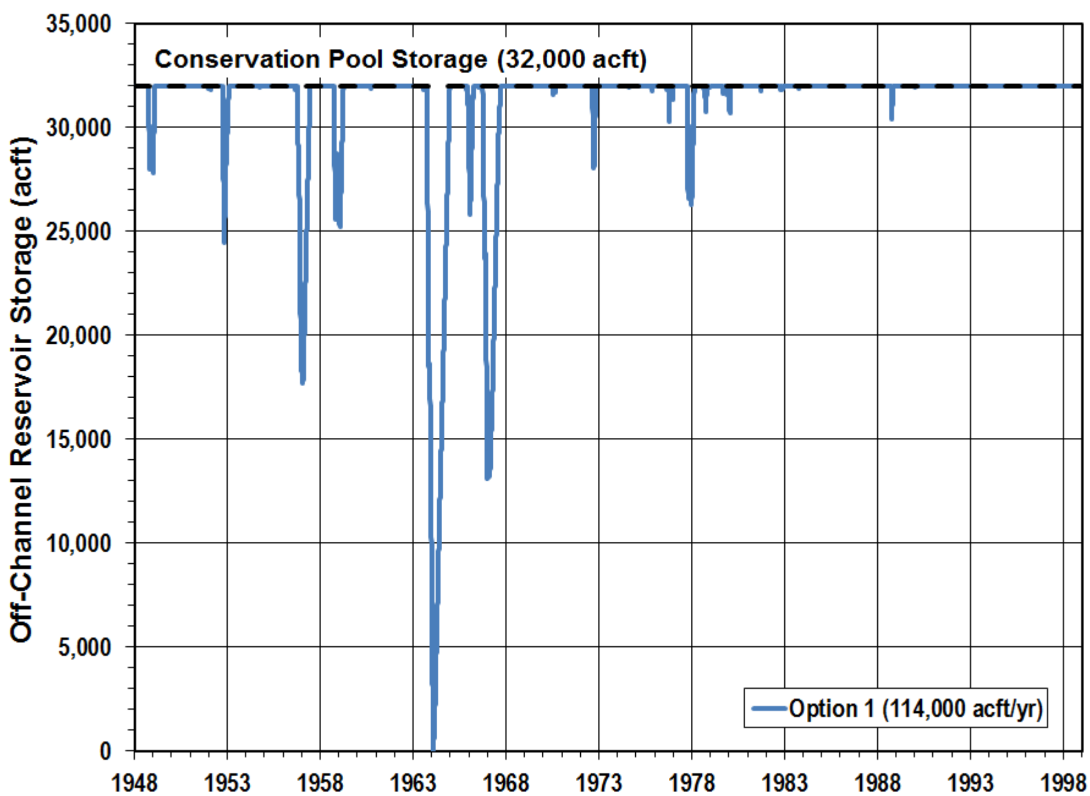
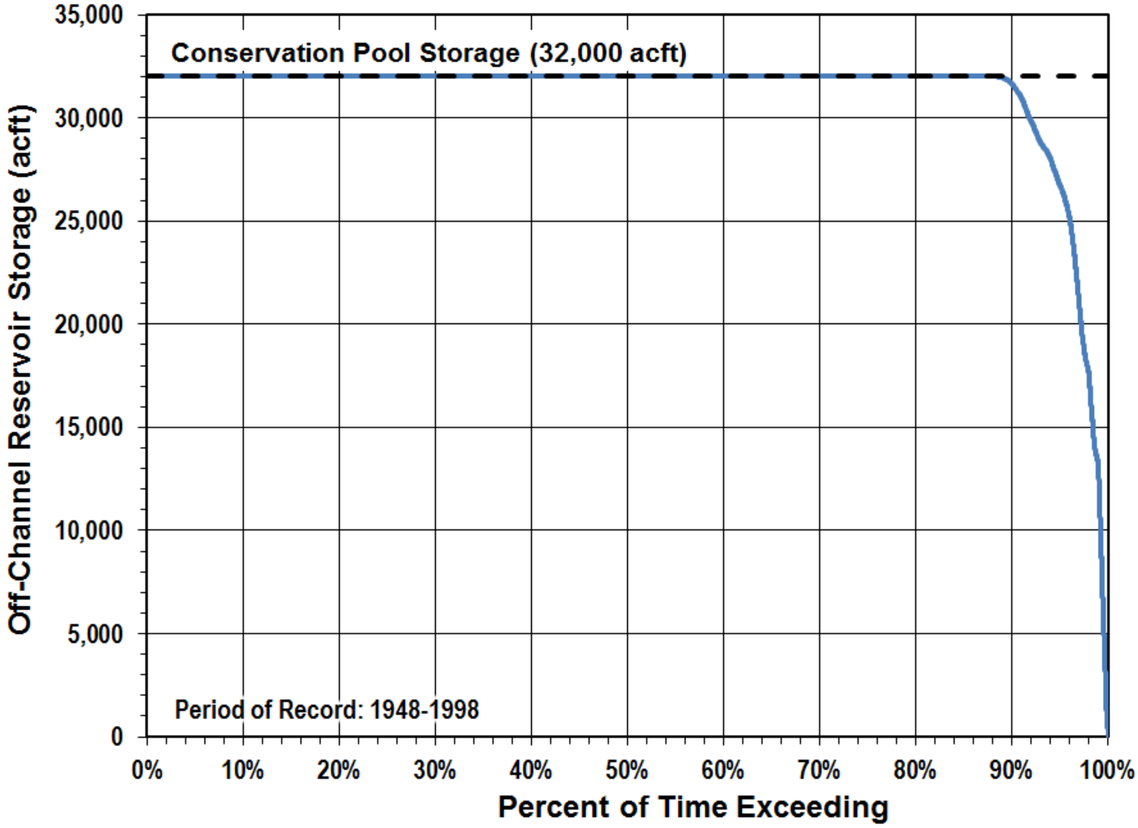


Figure 7.11-7. Frequency of Daily Storage of Red River OCR



7.11.3 Environmental Issues

Table 7.11-1 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 that would need further study in feasibility or permitting efforts to address potential concerns with respective regulatory agencies.

Habitat

River and transmission infrastructure would be located to avoid conflicts with environmentally sensitive areas where feasible. There are currently no areas of designated critical habitat within the project area. 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. 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 will be crossed by the pipeline corridor. These 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 will be disturbed during construction. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these 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.

Table 7.11-1. Environmental Factors for Red River OCR

Environmental Factors	Comment(s)	Level of Concern
Habitat	No presence of critical or unique habitat in project area.	Low
Environmental Water Needs	Low Impact	Low
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Low Impact American peregrine falcon ST, bald eagle ST, Bachman's sparrow ST, Eskimo curlew FE and SE, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, whooping crane FE and SE, wood stork ST, blackside darter ST, blue sucker ST, creek chubsucker ST, paddlefish ST, shovelnose sturgeon ST, American burying beetle FE, black bear ST, red wolf FE and SE, Ouachita rock pocketbook FE, Texas heelsplitter ST, alligator snapping turtle ST, Texas horned lizard ST, and timber rattlesnake ST.	Low
Wetlands	Low Impact	Low

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

Environmental Water Needs

Implementation and operation of the Red River OCR project will have a limited impact on daily flows in the Red River since average gaged streamflow from 1998 to 2013 have been over 13 million acft/yr (Table 7.11-1), and the 162 MGD intake facility would divert less than 2 percent of the flows on average.

Bays and Estuaries

The Red River OCR Project will not affect an estuary system as it eventually flows into the Mississippi River system.

Threatened and Endangered Species

The species included in Table 7.11-1 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 twenty three species that meet these criteria. 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 best management practices (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 are not expected to present a significant challenge to the feasibility of the project.

Wetlands

Although a number of 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.

7.11.4 Planning Cost Estimate

The Red River OCR Project requires a 162 MGD river intake and pumping facility to be constructed on the Red River and a 2 mile, 84-in transmission pipeline to deliver the supplies to three OCRs. A 129 MGD OCR intake facility and a 100 mile, 84-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 7.11-2. Annual costs include estimates for periodic dredging of the sedimentation basins and chemical addition for zebra mussel control. The costs presented in Table 7.11-2 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 $853 million with annual costs for the project assuming a 30-year debt service estimated at $84.2 million per year. The unit cost of water for this project to deliver water to Lake Ray Roberts would be about $738 per acft or $2.27 per 1,000 gallons. After debt service, the unit cost of water would decrease to $224 per acft or $0.69 per 1,000 gallons.

An upsized version of this project was evaluated during the course of the Dallas LRWSP capable of delivering 310,000 acft per year, or 276.5 MGD, to multiple entities in the DFW Metroplex area. This option requires a 484 MGD river intake and pumping facility to be constructed on the Red River and a 2 mile, 132-in transmission pipeline to deliver the raw water to three OCRs. A 345 MGD OCR intake facility and a 100 mile, 144-in transmission pipeline would need to be constructed to deliver supplies to Lake Ray Roberts or other drop off locations along the route. Total project costs for the larger version are $1,718.4 million with annual costs for the project assuming 30-year debt service estimated at $171.2 million per year. The unit cost of water for this project to deliver water to Lake Ray Roberts would be about $552 per acft or $1.69 per 1,000 gallons. After debt service, the unit cost of water would decrease to $171 per acft or $0.52 per 1,000 gallons.

Table 7.11-2. Cost Estimate Summary for Red River Off-Channel Reservoir

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Off-Channel Storage Reservoir	$127,951,000
Red River Intake, Pump Station and Channel Dam	$22,367,000
Transmission Pipeline from Red River to Off-Channel Reservoir	$8,012,000
Off-Channel Reservoir Intake and Pump Station	$27,541,000
Transmission Pipeline from Off-Channel Reservoir to Lake Ray Roberts	$366,413,000
Transmission Pump Station and Storage Tank	$20,026,000
TOTAL COST OF FACILITIES	**$572,310,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$181,587,000
Environmental & Archaeology Studies and Mitigation	$ 5,284,000
Land Acquisition and Surveying (3,286 acres)	$ 12,752,000
Interest During Construction (4% for 2 years with a 1% ROI)	$ 81,054,000
TOTAL COST OF PROJECT	**$ 852,987,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$ 58,690,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$ 5,493,000
Dam and Reservoir	$1,919,000
Zebra Mussel Treatment	$2,697,000
Pumping Energy Costs (0.08 $/kW-hr)	$13,470,000
Sediment Dredging	$1,919,000
TOTAL ANNUAL COST	**$84,188,000**
Available Project Yield (acft/yr)	**114,000**
Annual Cost of Water ($ per acft)	**$738**
Annual Cost of Water ($ per 1,000 gallons)	**$2.27**
Annual Cost of Water after Debt Service ($ per acft)	**$224**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.69**

7.11.5 Permitting and Implementation Issues

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 need to obtain a 404 permit from the USACE for impacts to a waterway from construction activities. Table 7.11-3 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 7.11-3. 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.
404	USACE	Required for construction activities in waters of the US.

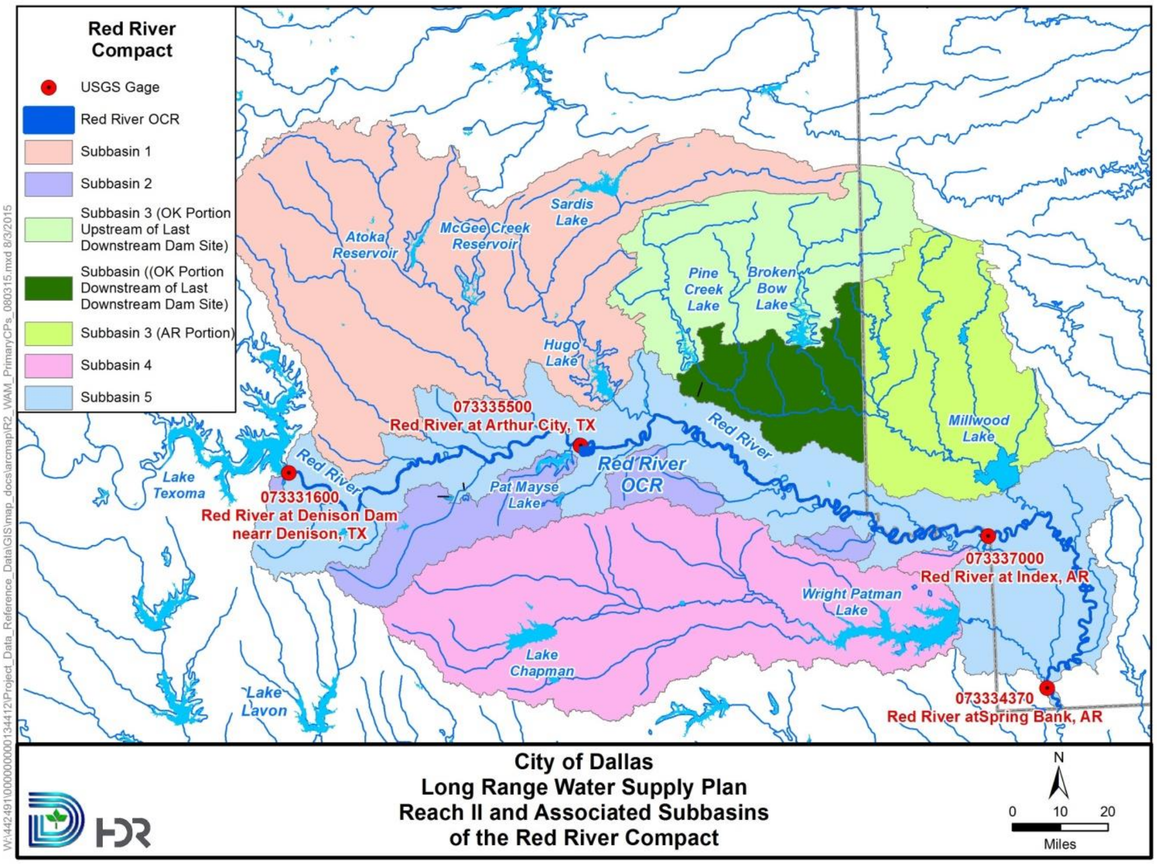
Diversion from the Red River would also need to comply with all provisions included in the Red River Compact[1]. The diversion at Arthur City would be located in Reach II, Subbasin 5 of the Red River Compact. Under Section 5.05 of the Compact, the main stem of the Red River within Reach II (i.e. subbasin 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 7.11-8 provides the Reach II associated subbasin boundaries as defined by the Red River Compact. In addition, Figure 7.11-8 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 7.11-4 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 2013 gage period of record. Table 7.11-4 also provides the approximate portion of available flows of subbasin 5 that Texas is entitled to. On average, Texas is entitled to

[1] http://www.statutes.legis.state.tx.us/Docs/WA/htm/WA.46.htm

almost 3 million acft/yr of the available flow in subbasin 5. For comparison purposes, Texas currently has 517,094 acft/yr of permitted diversions in all of Reach II including the Sulphur River basin. In the minimum year of the gage period of record (2006) there was 675,039 acft of available flow to Texas in subbasin 5.

Figure 7.11-8. Reach II and Associated Subbasins of the Red River Compact



This amount of available flow is about 2 million 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 7.11-4 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.

7.11.6 Project Risk and Alternatives

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 Section 7.11.5. 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 7.11-4. 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	6,993,001	1,222,829
Average	**13,390,185**	**2,830,110**
Min (2006)	**4,550,219**	**675,039**

7.11.7 Agricultural and Natural Resources

The OCR would permanently impact an estimated 399 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 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 Environmental Impacts section above.

7.12 Sulphur River Basin Project

The 2014 LRWSP is relying on the Sulphur River Basin Authority's Sulphur Basin Study[1,2] results for this water management strategy. As of the writing of the 2014 Dallas LRWSP, the Sulphur Basin Study has not produced a report with a final recommendation. The recommendation included in this write up was preliminarily recommended at a Joint Committee for Planning for Program Development (JCPD) meeting in September of 2014. Freese and Nichols, the consultant on the study, provided data and strategy evaluations to Dallas who passed the recommendations on to HDR for inclusion in the 2014 LRWSP. The information presented herein is the most up to date, but not yet finalized from the Sulphur Study. This strategy is included as a placeholder and an alternative strategy for Dallas to participate in if the Sulphur basin study continues to move forward.

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 7.12-1 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 study includes several participants referred to as the Joint Committee for Planning for Program Development (JCPD) which includes Tarrant Regional Water District (TRWD), North Texas Municipal Water District (NTMWD), Upper Trinity Regional Water District (UTRWD), and the Cities of Dallas and Irving, along with in-basin users represented by the SRBA.

7.12.1 Strategy Description

As part of the Sulphur study, options being studied for developing potential additional water supply included reallocating flood storage in Wright Patman and the construction of Marvin Nichols Reservoir. The Sulphur River Basin project, if constructed, would be shared between the JCPD members.

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 yield could be generated if a portion of the flood storage in Wright Patman Lake were reallocated to municipal use. The City of Texarkana has contracted with the USACE for

[1] 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

[2] 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

storage in the lake and holds a water right permit to use up to 180,000 acre-feet per year (161 MGD) from the lake.

Reallocation options include increasing the capacity of the conservation pool by either raising the maximum conservation elevation and/or lowering the minimum conservation elevation. Table 7.12-1 summarizes the increases in firm yield by adjusting the conservation pool elevations.

Figure 7.12-1. Sulphur River Basin Project

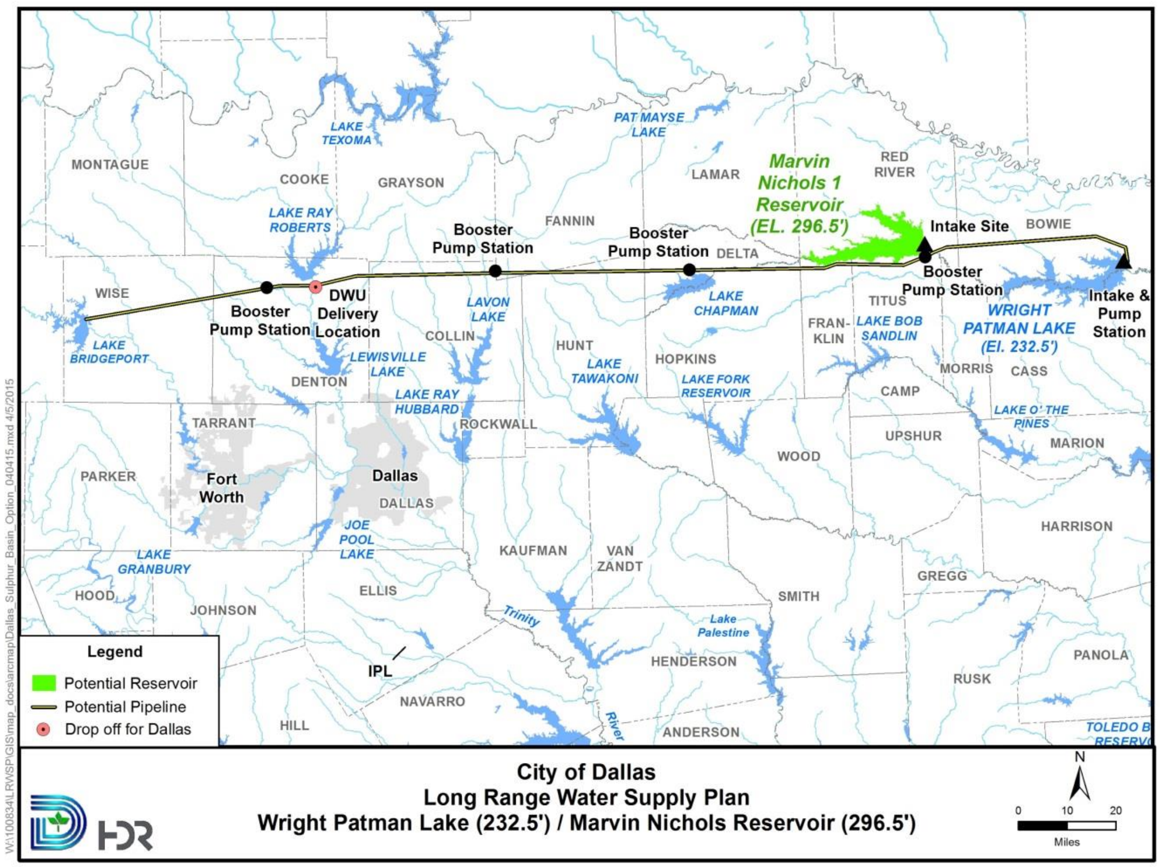


Table 7.12-1. Summary of Wright Patman Firm Yields for Various Conservation Pools

Max Conservation Pool Elevation	Min Conservation Pool Elevation	Sediment Condition	Firm Yield (acft/yr)
232.5	223	Current	385,753
232.5	220	Current	460,963
232.5	217.5	Current	505,873
232.5	None (total capacity)	Current	557,353

A reservoir at the Marvin Nichols site (refer to Figure 7.12-1) is 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[3]. 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 Marvin Nichols project would be located on the Sulphur River in Red River and Titus counties approximately halfway between the cities of Clarksville and Mount Pleasant. At this location, the reservoir would have a total drainage area of 1,889 square miles (of which 479 square miles are above Lake Chapman.) For the selected strategy in the 2014 LRWSP, the top of the conservation pool is 296.5 feet-msl NGVD. This is a downsized version compared to the Marvin Nichols site in the 2011 Region C RWP.

Supplies from Wright Patman and 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 7.12-1 and Table 7.12-2.

Table 7.12-2. Delivery Locations and Peaking Rates for Delivery of Sulphur River Supplies

	TRWD	DWU	NTMWD	UTRWD	Irving	SRBA
Peaking	1.25	1.5	1.4	1.25	1.25	1.25
Delivery Location	Lake Bridgeport	Trinity River & Lake Ray Roberts	NWTP & Wylie WTP	Trinity River & Lake Ray Roberts	Trinity River & Lake Ray Roberts	Unspecified
Raw Water Ownership	23.918%	23.358%	23.918%	4.807%	4%	20%
Metroplex JCPD Sections	29.897%	29.197%	29.897%	6.009%	5%	0%

7.12.2 Water Availability

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 180,000 ac-ft./yr (161 MGD). However, the TCEQ WAM model for the Sulphur River Basin suggests that the reliable supply from

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

Wright Patman Lake under current conditions is approximately 46,000 ac-ft./yr (41 MGD) due to the limited size of the available conservation pool.

Based on the data from the Sulphur Basin Study, combined yield associated with reallocating Wright Patman to 232.5 ft-msl and construction of Marvin Nichols with a conservation pool at 296.5 ft-msl, and considering environmental flows results in a combined project yield of 543,197 acft/yr (485 MGD).

The 2011 Region C RWP estimated a yield of Marvin Nichols Reservoir of 612,300 acft/yr (547 MGD) assuming that the proposed Lake Ralph Hall is in place as a senior water right and that releases are made for downstream water rights and the environmental flows as required by TWDB environmental flow criteria. The 2011 yield analysis assumes that the reservoir will be operated as a system with Wright Patman Lake, protecting Wright Patman Lake's senior water right.

7.12.3 Environmental Issues

Table 7.12-3 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.

Habitat

The footprints of both the Wright Patman and Marvin Nichols projects contain heavily forested areas, and agricultural areas including crops and pasture. Impacts to preferred habitats within the reservoir areas will be minimized to some extent by utilizing the agricultural areas which have been previously disturbed. 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 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 Texas Parks and Wildlife Department 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, bottomland hardwood vegetation and barren areas which cover approximately one half of the project area. The Sulphur Basin Study reported that 12,151 acres of impacted WOTUS occur within Marvin Nichols Reservoir. Three cemeteries exist within this project area which would require coordination with the Texas Historical Commission to relocate.

Environmental Water Needs

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

Bays and Estuaries

The Sulphur Basin Project will not affect a Texas estuary system as it eventually flows into the Mississippi River system.

Threatened and Endangered Species

The species included in Table 7.12-3 represent all species federally or state listed as threatened or endangered, and federal candidate species in the affected counties. These projects include twenty six species that meet these criteria. These species would need to be considered and potentially mitigated for during project permitting and implementation. Considering the numbers of listed species and the large number of acres affected by these two projects the impacts to species would be considered medium.

Wetlands

Data provided by the Sulphur Basin study for the Wright Patman reservoir indicates that 12,525 acres of potential wetland areas. The Marvin Nichols project area includes 12,151 acres of potential wetland areas. These areas would be mitigated in accordance with required federal regulations as administered through the US Army Corps of Engineers section 404 permitting process.

Table 7.12-3. Environmental Factors for Sulphur Basin Project

Environmental Factors	Comment(s)	Level of Concern
Habitat	Bottomland hardwood areas present	High
Environmental Water Needs	Medium Impact	Medium
Bay and Estuary	Low Impact	Low
Threatened and Endangered Species	Medium impact American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, wood stork ST, blackside darter ST, bluehead shiner ST, creek chubsucker ST, paddlefish ST, shovelnose sturgeon ST, American burying beetle FE, black bear ST, Louisiana black bear FT and ST, Rafinesque's bit-eared bat ST, red wolf FE and SE, Louisiana pigtoe ST, Ouachita rock pocketbook FE, Southern hickorynut ST, Texas pigtoe ST, alligator snapping turtle ST, Northern scarlet snake ST, Texas horned lizard ST, and timber rattlesnake ST	Medium
Wetlands	Wetland areas are present within both project areas	High

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

7.12.4 Planning Cost Estimate

The Sulphur River Basin project will be shared between the JCPD members. The total cost to construct Marvin Nichols reservoir, reallocate storage in Wright Patman and construct transmission system to deliver 543,197 acft/yr (485 MGD) is $4.8 billion. Annual costs are $403 million including debt service, operation, maintenance, and pumping costs. Costs are shown in Table 7.12-4 for Dallas' portion of costs for the Sulphur River Basin project to deliver 102 MGD (114,000 acft/yr) of supply to the Trinity River Basin near Lake Ray Roberts based on November 2013 prices. (Note: These costs come from Sulphur Basin Study data provided in July of 2014 which contains the latest opinion of probable cost. Although comparable to costs developed in the Unified Costing Model for other Dallas projects, differing assumptions are used for calculating interest during construction (4% less 1% return), debt service period (40 years) and cost of energy ($0.07/kwhr). The cost summary from the Sulphur Basin study uses a different method of presenting the costs than the Unified Costing Model. For example, the contingencies that are shown as a separate line item on the cost estimates of the other strategies are included in the various line items for specific pieces of infrastructure in this cost estimate. The decision was made to report the cost of this project based on the Sulphur study and not convert the prices using the Unified Costing Model. This allows the reader to more easily track these costs back to the original study.)

Total project costs to Dallas are estimated to be $1,003 million (about 21% of the total project costs as compared to Dallas's 23.9% ownership share as shown in Table 7.12-2.) with annual costs for the project assuming a 40-year debt service estimated at $84.6 million per year. The unit cost of water for this project would be about $742 per acft or $2.28 per 1,000 gallons. After debt service, the unit cost of water would decrease to $194 per acft or $0.60 per 1,000 gallons.

Table 7.12-4. Cost Estimate Summary for Dallas Portion of Selected Sulphur River Basin Projects

Table units: November 2013 Dollars from Sulfur Basin Study Estimate

Item	Estimated Cost for Facilities	Estimated Cost for DWU Portion of Facilities
RESERVOIR FACILITIES		
Dam and Spillway	$269,581,000	$56,577,000
Reservoir Land Acquisition (27,382 acres)	$52,166,000	$10,948,000
Reservoir Conflicts	$55,928,000	$11,738,000
Reservoir Mitigation	$320,103,000	$67,180,000
Reservoir Permitting	$21,567,000	$4,526,000
Reservoir Interest During Construction	$87,523,000	$18,368,000
TOTAL COST OF RESERVOIR FACILITIES	**$806,868,000**	**$169,337,000**
TRANSMISSION FACILITIES		
Pipeline	$2,576,324,000	$540,690,000
Pump Stations	$623,392,000	$130,830,000
Interest During Construction	$773,275,000	$162,286,000
TOTAL COST OF TRANSMISSION FACILITIES	**$3,972,991,000**	**$833,806,000**
TOTAL COST OF PROJECT	**$4,779,859,000**	**$1,003,143,000**
ANNUAL COST		
Non Reservoir Debt Service (5.5 percent, 40 years)	$247,605,000	$51,965,000
Reservoir Debt Service (5.5 percent, 40 years)	$50,284,000	$10,553,000
Operation and Maintenance		
Reservoir	$4,852,000	$1,018,000
Intake, Pipeline, Pump Station	$37,006,000	$7,766,000
Pumping Energy Costs (kW-hr @ 0.07 $/kW-hr)	$63,538,000	$13,335,000
TOTAL ANNUAL COST	**$403,285,000**	**$84,637,000**
Available Project Yield (acft/yr)	**$543,197**	**114,000**
Annual Cost of Water ($ per acft)	**$742**	**$742**
Annual Cost of Water ($ per 1,000 gallons)	**$2.28**	**$2.28**
Annual Cost of Water after Debt Service ($ per acft)	**$194**	**$194**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.60**	**$0.60**

Source: 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

7.12.5 Permitting and Implementation Issues

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 7.12-5.

Table 7.12-5. Summary of Required Major Permits for Suphur River Basin Projects

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

7.12.6 Project Risk and Alternatives

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 Sulphur Basin project possesses a high level of risk associated with permitting as discussed in Section 7.12.5. In addition, this project is susceptible to performance risk associated with a worse drought of record and future increases in reservoir evaporation from increasing temperature.

7.12.7 Agricultural and Natural Resources

The project would permanently impact an estimated 10,824 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils. 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.

7.13 Toledo Bend Reservoir to Dallas West System

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 million acft and has a yield of approximately 1.5 million acft/yr. SRA Texas holds a Texas water right to divert 750,000 acft/yr (670 MGD) from Toledo Bend. Up to 700,000[1] acft/yr is being considered for transport from Toledo Bend to other lakes in Texas.

7.13.1 Strategy Description

Dallas, TRWD, NTMWD, and SRA Texas have been collaborating for many years on a potential transfer of water from Toledo Bend Reservoir to the upper Sabine River basin and to the Dallas-Fort Worth (DFW) Metroplex. Though the details of the potential transfer have changed over time, it is assumed for purposes of this analysis that a total of 700,000 acft/yr could be purchased with 100,000 acft/yr (89 MGD) being transferred to the upper Sabine River Basin and 600,000 acft/yr (536 MGD) being transferred to the DFW Metroplex. The 700,000 acft/yr (625 MGD) is assumed to be divided between the project partners as follows:

- Dallas Water Utilities – 200,000 acft/yr (179 MGD or 28.6%)
- NTMWD – 200,000 acft/yr (179 MGD or 28.6%)
- TRWD – 200,000 acft/yr (179 MGD or 28.6%)
- SRA Texas – 100,000 acft/yr (89 MGD or 14.2%)

A shared 225 mile pipeline would be needed to deliver supplies between the reservoir and Dallas with deliveries to Dallas being assumed to be to the Joe Pool Lake area and other lakes along the route (Figure 7.13-1).

7.13.2 Water Availability

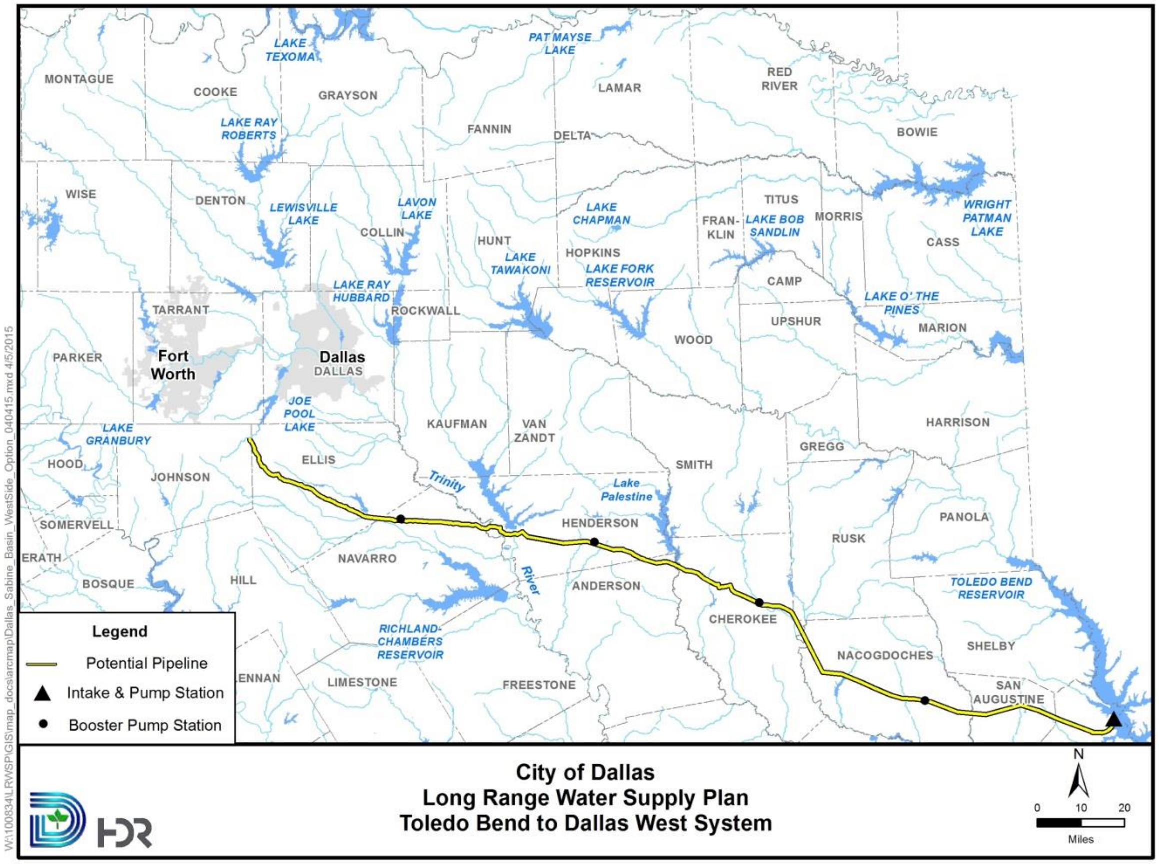
SRA Texas holds a Texas water right permit to divert 750,000 acft/yr (670 MGD) from Toledo Bend Reservoir and is seeking the right to divert an additional 293,300 acft/yr (262 MGD). For purposes of this analysis, up to 700,000 acft/yr is being considered for transport to Dallas and other entities in the DFW Metroplex. This project would provide 200,000 acft/yr to Dallas.

7.13.3 Environmental Issues

Table 7.13-1 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 effort to address these potential concerns with the respective regulatory agencies.

[1] 2011 Region C Water Plan

Figure 7.13-1. Toledo Bend Reservoir to Dallas' West System



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.

Habitat

Although, not finalized, the proposed pipeline route will cross sections of the Sabine National Forest, three Texas Parks and Wildlife Department designated ecologically significant stream segments, an area of U.S. Fish and Wildlife Service (USFWS) Priority 1 bottomland hardwoods, and USFWS designated critical habitat areas for the endangered Texas golden gladecress. The pipeline route crosses portions of ten 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.

Depending on the ultimate design, the transfer of water between water bodies could result in potential environmental impacts due to altered biodiversity, competition between introduced and native species, additional distribution of invasive species and changes to water quality.

Environmental Water Needs

Implementation and operation of this strategy could have a medium impact on daily flows in the Sabine River due to the amount of supply diverted from storage that might have been previously passed downstream. However, it will leave adequate flows in the Sabine River to meet required TCEQ environmental flow requirements.

Bays and Estuaries

Transporting of supplies out of the basin will impact flows to Sabine Lake and its estuary downstream of Toledo Bend Reservoir. Freshwater stream flows are critical to the health of the Sabine estuary system. Quantifying that impact will require additional detailed analysis.

Threatened and Endangered Species

The species included in Table 7.13-1 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 forty one species that meet these criteria. 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 best management practices (BMPs) during design and construction activities are 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.

Wetlands

Although a number of 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.

7.13.4 Planning Cost Estimate

The total project costs for this estimate are taken from the Toledo Bend Strategy contained in the 2011 Region C RWP, and only the debt service calculations were modified for use in the 2014 Dallas LRWSP. Shared project facilities will include a 781 MGD intake and pump station at Toledo Bend Reservoir, 225 miles of parallel 144-inch diameter and 108-inch diameter transmission pipeline, and 4 booster pump stations. The system is sized for a 1.1 peaking factor. The route parallels the Integrated Pipeline (IPL) route between Lake Palestine and Joe Pool Lake.

A summary of the total project costs of the project for the Toledo Bend pipeline is listed in Table 7.13-2 for both the entire project and Dallas' portion. Dallas' portion of the total project costs are $2.3 billion. Annual costs for the project assume a 30 year debt service with a 5.5 percent interest rate and Dallas' portion is estimated to be $204,709,000 per year. Based off of previous planning estimates, the raw water purchase cost from SRA of Texas is estimated at $22/acft/yr. 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 $1,024 per acft or $3.14 per 1,000 gallons. After debt service, the unit cost of water would decrease to $236 per acft or $0.72 per 1,000 gallons.

Table 7.13-1. Environmental Factors for Toledo Bend to Dallas' West System

Environmental Factors	Comment(s)	Level of Concern
Habitat	Medium Impact – due to the number of miles impacted	Medium
Environmental Water Needs	Medium Impact	Medium
Bays and Estuaries	Medium Impact	Medium
Threatened, Endangered and Candidate Species	Low impact Swallow-tailed kite ST, American peregrine falcon ST, Bachman's sparrow ST, bald eagle ST, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, red-cockaded woodpecker FE and SE, white-faced ibis ST, whooping crane FE and SE, wood stork ST, blue sucker ST, golden-cheeked warbler FE and SE, black-capped vireo FE and SE, sharpnose shiner FE, smalleye shiner FE, gray wolf FE and SE, black bear ST, Louisiana black bear, FT and ST, red wolf FE and SE, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, earth fruit FT and ST, creek chubsucker ST, paddlefish ST, Rafinesque's big eared bat ST, Louisiana pine snake C and ST, northern scarlet snake ST, Neches River rose mallow FT, Texas golden gladecress FE, white bladderpod FE and SE, Texas fawnsfoot C and ST, Louisiana pigtoe ST, sandbank pocketbook ST, southern hickorynut ST, Texas heelsplitter ST, Texas pigtoe ST, and triangle pigtoe ST.	Low
Wetlands	Medium to Low Impact	Low

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

7.13.5 Permitting and Implementation Issues

The Toledo Bend Pipeline project would pose several permitting challenges along with the typical challenges associated with a new project, summarized in Table 7.13-3. 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 inter-basin transfer authorization to allow the water to be used in the Trinity River Basin. A Section 404 permit from the USACE for impacts to a waterway will be needed for construction of the diversion facilities and pipeline.

Table 7.13-2. Cost Estimate for Dallas Portion of Toledo Bend Pipeline to Dallas' West System

Table units: September 2013 Dollars

Item	Estimated Cost of Facilities	Estimated Portion of Dallas' Cost of Facilities
CAPITAL COST		
Intake Pump Station	$115,021,000	$32,863,000
Transmission Pipeline (452 miles of 108 – 144 in dia.)	$4,382,378,000	$1,252,108,000
Transmission Pump Station(s) & Storage Tank(s)	$414,411,000	$118,403,000
TOTAL COST OF FACILITIES	**$4,911,810,000**	**$1,403,374,000**
OTHER PROJECT COSTS		
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$1,500,016,000	$428,576,000
Environmental & Archaeology Studies and Mitigation	$7,903,000	$2,258,000
Land Acquisition and Surveying (7,385 acres)	$18,204,000	$5,201,000
Interest During Construction (4% for 7 years with a 1% ROI)	$1,577,296,000	$450,656,000
TOTAL COST OF PROJECT	**$8,015,229,000**	**$2,290,065,000**
ANNUAL COST		
Debt Service (5.5 percent, 30 years)	$551,491,000	$157,569,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	$54,849,000	$15,671,000
Pumping Energy Costs (0.08 $/kW-hr)	$94,742,000	$27,069,000
Purchase of Water ($22/acft)	$15,400,000	$4,400,000
TOTAL ANNUAL COST	**$716,482,000**	**$204,709,000**
Available Project Yield (acft/yr)	**700,000**	**200,000**
Annual Cost of Water ($ per acft)	**$1,024**	**$1,024**
Annual Cost of Water ($ per 1,000 gallons)	**$3.14**	**$3.14**
Annual Cost of Water after Debt Service ($ per acft)	**$236**	**$236**
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	**$0.72**	**$0.72**

Source: http://www.twdb.texas.gov/waterplanning/rwp/plans/2011/C/Region_C_2011_RWPV1.pdf

Table 7.13-3. Potential Permitting Requirements

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

7.13.6 Project Risk and Alternatives

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 Toledo Bend project is susceptible to permitting risk and competition. Supply volumes are not fixed until a contract is signed and current negotiations between SRA Texas and other entities in Southeastern Texas could reduce Dallas', NTMWD's, TRWD's proposed portion of supply, unless SRA Texas can secure additional water. SRA Texas is seeking the right to divert an additional 293,300 acft/yr from TCEQ. Without sufficient supply, the project could become cost prohibitive.

7.13.7 Agricultural and Natural Resources

Construction activities associated with the project transmission pipeline will impact an estimated 438 acres of soils identified by the U.S. Department of Agriculture (USDA) as prime farmland soils within 10 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.

7.13.8 References

Freese and Nichols, Inc.; Alan Plummer Associates, Inc.; CP&Y, Inc.; and Cooksey Communications, Inc. 2010. "Volume 1 of 3, Main Report." 2011 Region C Water Plan. Prepared for Region C Water Planning Group.
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http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/0704830694_RegionI/Special%20StudyNo1.pdf

7.14 Lake Texoma Pipeline and Advanced Water Treatment Plant

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.

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 316,550 acft/yr (283 MGD) and has already been fully permitted by the TCEQ to other Texas entities. According to the USACE an additional supply of 220,000 acft/yr (196 MGD) 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, available supply from Oklahoma's portion of the municipal supply could be purchased by DWU if Oklahoma entities were willing to sell some part of the allocation.

7.14.1 Strategy Description

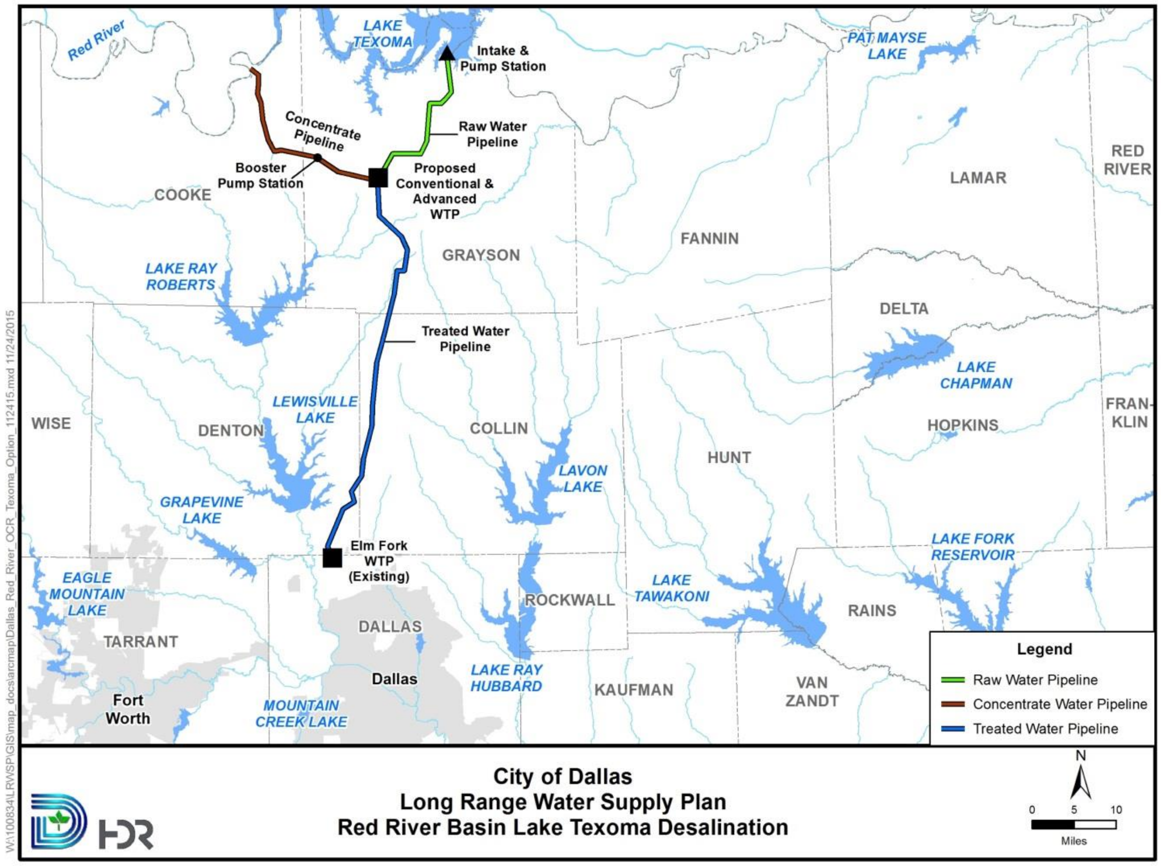
Up to 162,271 acft/yr of Oklahoma's share of the Lake Texoma water supply may be available if Oklahoma entities were willing to sell some part of the allocation. This would require a contract or permit between Oklahoma entities and DWU.

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 7.14-1 shows Lake Texoma's location in relation to the Dallas system, along with the proposed pipeline routes, and proposed location of the treatment facility.

7.14.2 Water Availability

Although the potential water supply capability of Lake Texoma is very large, none of its unutilized yield is currently available to Texas entities. Potentially, up to 162,271 acft/yr (145 MGD) of Oklahoma's share of Lake Texoma could be made available if Oklahoma entities were willing to sell all or a portion of the allocation to Texas. This would require a contract or permit between Oklahoma entities and DWU. An additional supply of 220,000 acft/yr (196 MGD) could potentially be made available to Texas entities if the U.S. Congress would authorize the reallocation of hydropower storage in to municipal water supply.

Figure 7.14-1. Lake Texoma Desalination



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[1] 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[2] prepared for Dallas 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 stand 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.

[1] Oklahoma Department of Environmental Quality, 2012. "Water Quality in Oklahoma, 2012 Integrated Report." Appendix C.

[2] HDR Engineering, Inc. (HDR) 2005. "Cost Evaluation of Two Options to Deliver Lake Texoma Water to City of Dallas." Prepared for Dallas Water Utilities.

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.

7.14.3 Environmental Issues

Table 7.14-1 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 that would need further study in feasibility or permitting efforts 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, 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[3] 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.

Habitat

The proposed pipelines will cover nearly 100 miles through five counties which include 24 state and federally listed endangered or threatened, or federal candidate species which use the various area habitats. 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. Wooded riparian areas commonly occur along and adjacent to stream and river crossings that will be crossed by the pipeline corridor. These areas are commonly utilized by many different species and should be avoided as much as reasonably possible. The pipeline route will also cross wetland areas which will be disturbed during construction. The use of best management practices (BMPs) during construction activities will help to minimize potential impacts to these areas.

However, 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.

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

[3] Storage Reallocation Report Lake Texoma Oklahoma and Texas, United States Army Corps of Engineers, Tulsa District, March 2010. http://www.swt.usace.army.mil/Portals/41/docs/library/texoma_reallocation/01%20Main%20and%20App%20A%20thru%20G%20Texoma%20MARCH%202010%20FINAL%20and%20Addendum.pdf

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.

Bays and Estuaries

The Lake Texoma project will not affect an estuary system as the Red River eventually flows into the Mississippi River system.

Threatened and Endangered Species

The species included in Table 7.14-1 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 twenty four species that meet these criteria. 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 best management practices (BMPs) during design and construction activities are 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.

Wetlands

Although a number of 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.

7.14.4 Planning Cost Estimate

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 clearwells for distribution within the DWU system.

The breakdown of the supply as related to facility capacities is outlined below:

- Entire supply of 162,271 acft/yr (145 MGD average annual / 181 MGD with a 1.25 peaking factor) 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.

Table 7.14-1. Environmental Factors for Lake Texoma Pipeline

Environmental Factors	Comment(s)	Level of Concern
Habitat	Low	Low
Environmental Water Needs	Low Impact if Water is from Oklahoma share of Texoma Medium Impact if Water is from Hydro-power Reallocation	Low to Medium
Bays and Estuaries	Low Impact	Low
Threatened and Endangered Species	Medium Low impact American peregrine falcon ST, bald eagle ST, black-capped vireo FE and SE, eskimo curlew FE and SE, golden-cheeked warbler FE and SE, interior least tern FE and SE, peregrine falcon ST, piping plover FT and ST, Sprague's pipit C, whooping crane FE and SE, white-faced ibis ST, wood stork ST, Texas heelsplitter ST, Louisiana pigtoe ST, Texas pigtoe ST, alligator snapping turtle ST, Texas horned lizard ST, timber rattlesnake ST, blue sucker ST, creek chubsucker ST, paddlefish ST, shovelnose sturgeon ST, red wolf FE and SE, and gray wolf FE and SE.	Low
Wetlands	Low Impact	Low

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

A summary of DWU's portion of project and annual costs is listed in Table 7.14-2. Many of the DWU supply options are based on delivering raw water to the city and assumptions of WTP expansions. However, due to the impaired water quality at Lake Texoma, treatment costs are included in order to produce a potable supply. Therefore, to appropriately compare this strategy to other strategies within the 2014 Dallas LRWSP (which only include costs associated with delivering raw water to one of the Dallas WTPs), the cost that Dallas would avoid associated with the expansion of an existing conventional treatment plant (162.9 MGD) is subtracted from the total cost. 162.9 MGD is the 130.3 MGD average annual supply delivered with a 1.25 peaking factor.

Total project costs are $1.382 billion which includes avoided costs of $205 Million to expand one of Dallas' WTPs. This is shown as a negative value in the table. Annual costs for the project assume a 30 year debt service and a 5.5 percent interest rate are estimated to be $94,815,000 per year. The unit cost of water for this project to deliver water to the Elm Fork WTP would be about $1,153 per acft or $3.54 per 1,000 gallons. After debt service, the unit cost of water is decreased to $645 per acft or $1.98 per 1,000 gallons.

Table 7.14-2. Cost Estimate Summary for Lake Texoma Pipeline and Advanced WTP

Table units: September 2013 Dollars

Item	Estimated Cost for Facilities
CAPITAL COST	
Intake Pump Stations (181.1 MGD)	$55,157,000
Transmission Pipeline (90 in dia, 25 mi; 30 in dia, 27 mi; 84 in dia, 55 mi)	$318,022,000
Transmission Pump Station(s) & Storage Tank(s)	$4,739,000
Water Treatment Plant (Level 3 & Level 4: RO treatment @ 90.6 MGD, peak + a new conventional plant @ 181.1 MGD, peak)	$626,805,000
TOTAL COST OF FACILITIES	**$1,004,723,000**
OTHER PROJECT COSTS	
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$335,752,000
Environmental & Archaeology Studies and Mitigation	$2,960,000
Land Acquisition and Surveying (1,914 acres)	$7,574,000
Interest During Construction (4% for 5 years with a 1% ROI)	$236,427,000
Avoided Cost (Less cost of expansion @ 162.9 MGD)	($205,297,000)
TOTAL COST OF PROJECT	**$1,382,139,000**
ANNUAL COST	
Debt Service (5.5 percent, 30 years)	$94,815,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$4,661,000
Water Treatment Plant	$77,245,000
Pumping Energy Costs (kW-hr @ 0.08 $/kW-hr)	$9,003,000
Purchase of Water (146,000 acft/yr @ 22 $/acft)	$3,212,000
Avoided Annual Cost (Less O&M, Debt Service for 162.9 MGD)	($20,530,000)
TOTAL ANNUAL COST	**$168,406,000**
Available Project Yield (acft/yr)	146,000
Annual Cost of Water ($ per acft)	$1,153
Annual Cost of Water ($ per 1,000 gallons)	$3.54
Annual Cost of Water after Debt Service ($ per acft)	$645
Annual Cost of Water after Debt Service ($ per 1,000 gallons)	$1.98

7.14.5 Permitting and Implementation Issues

Dallas would require a contract with some entity in Oklahoma that has permitted rights to Oklahoma's share of the yield through the 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.

As shown in Table 7.14-3, 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 waterway from construction activities.

Table 7.14-3. Potential Permitting Requirements

Permit	Lead Regulatory Agency	Comments / Challenges
Water Right Permit	TCEQ / OWRB	Will require an inter-basin transfer authorization.
404	USACE	Required for construction activities in waters of the US.
TPDES	TCEQ	Required for discharge of concentrate into Red River upstream of Lake Texoma.

7.14.6 Project Risk and Alternatives

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.

Pursuing additional Texas supplies from Lake Texoma has associated permitting risks since the Oklahoma legislature will also have 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. Alternatively, Dallas could pursue reallocation of hydropower storage to municipal water supply which has been studied; however, the U.S. Congress would have to approve this strategy and it would require coordination with power interests.

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 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.

7.14.8 References

OWRB, 2012. “Lower Washita Watershed Planning Region Report.” Oklahoma Comprehensive Water Plan.

http://www.owrb.ok.gov/supply/ocwp/pdf_ocwp/WaterPlanUpdate/regionalreports/OCWP_LowerWashita_Region_Report.pdf

HDR Engineering, Inc. (HDR), “Cost Evaluation of Two Options to Deliver Lake Texoma Water to City of Dallas.” Prepared for Dallas Water Utilities, 2005.

8 Water Treatment Plant and Raw Water Conveyance System Capacity Needs

This section summarizes water treatment plant and raw water conveyance system capacity needs based on water demand projections to 2070 and the recommended water supply strategies as discussed in Sections 6 and 7. A timeline is provided summarizing needed infrastructure improvements, capital cost implications, and a roadmap for implementing the recommendations provided in this report. Additional commentary is provided to capture benefits of the recommended projects and the risks associated with not completing or delaying a given project.

8.1 Introduction

The previous report sections discuss recommended (and alternative) strategies for additional water supplies and attempt to balance the needs between Eastern and Western Supply Subsystems. A number of water conveyance and treatment infrastructure improvements will be required as recommended strategies are implemented and water demands increase. Several improvements are already a part of Dallas' Capital Improvements Program (CIP). Others have been identified for inclusion in the CIP.

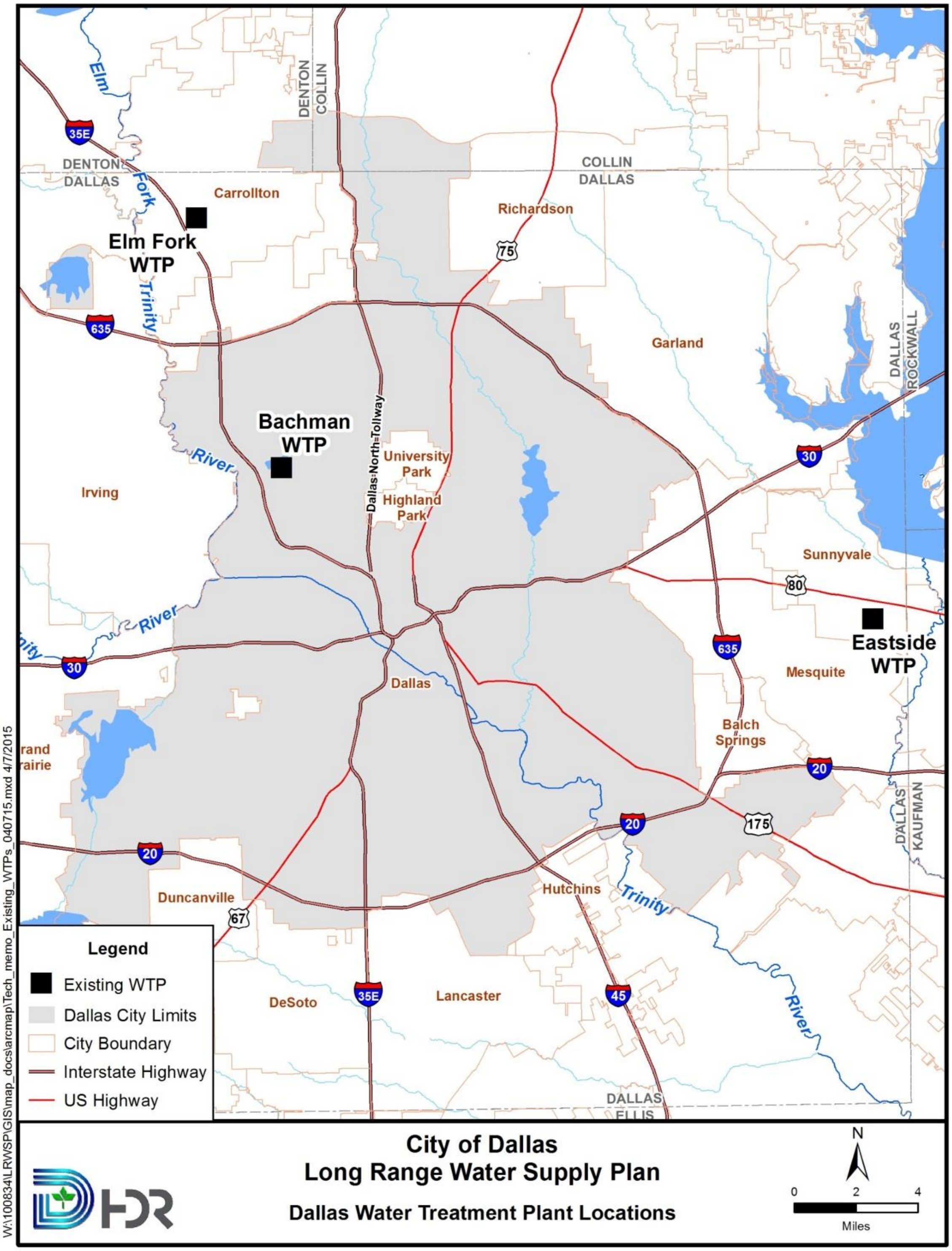
8.2 Existing Water Treatment Plants

The sections that follow provide a summary of the existing treatment facilities, the facilities role in serving treated water customers, and the existing facilities capacities.

8.2.1 Overview of Water Treatment Facilities

The Dallas Water Utilities (DWU) currently operates three large surface water treatment plants (WTPs) to serve its growing customer base. The Bachman and Elm Fork WTPs are part of the Western Supply Subsystem and the Eastside WTP is part of the Eastern Supply Subsystem. Each of these treatment plants uses conventional treatment processes with raw water (pre-) ozonation for added disinfection and oxidation of organic matter, lime softening, and chloramines as residual disinfectant. DWU is in various stages of preliminary design, detailed design, and construction at each of the treatment plants to implement its Water Quality Improvements (WQI) Program. The WQI Program objective is to enhance the chemical and biological stability of the treated water to address historical water quality challenges in the distribution system. Improvements include a process transition from the current lime softening approach to an enhanced organics removal strategy that includes biological filtration. At the Eastside WTP, these improvements have been coordinated with, and integrated into, the on-going plant expansion. Figure 8-1 shows the locations of the Dallas water treatment plants.

Figure 8-1. Dallas Water Treatment Plant Locations

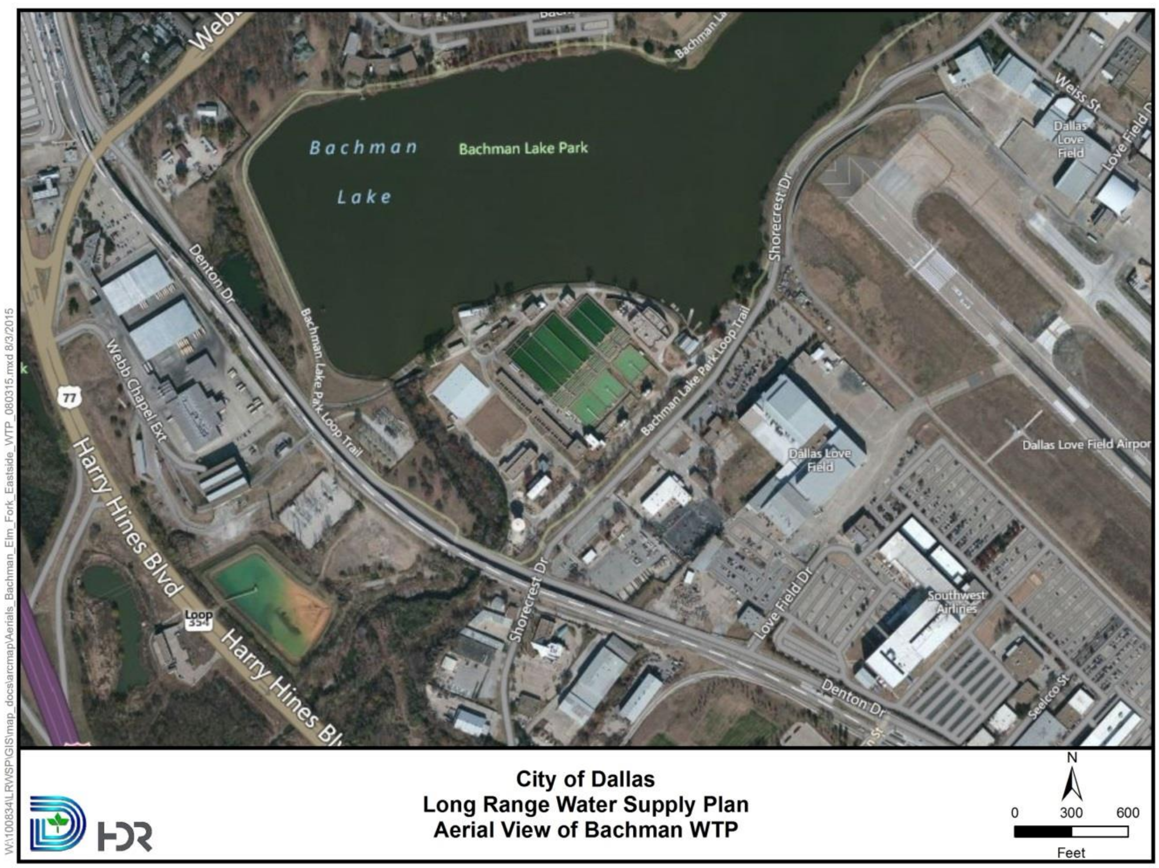


Bachman Water Treatment Plant

The Bachman WTP is Dallas' oldest water treatment facility with portions of the facility being constructed in 1930. The plant is located adjacent to Bachman Lake in Dallas. Its raw water intake is located north of Frazier Dam on the Elm Fork of the Trinity River. The intake diverts water into Fishing Hole Lake which serves as a natural sedimentation basin upstream of the treatment process. Water then flows through an intake and piping system at Fishing Hole Lake to the Raw Water Pump Station where raw water is pumped to the treatment plant.

Figure 8-2 provides an aerial view of the Bachman WTP. The plant is bound on all sides by existing development and Bachman Lake. With the WQI Program construction set to begin, there is limited available site space to accommodate further expansion using conventional WTP processes without going to a multi-level conventional or an advanced treatment process.

Figure 8-2. Aerial View of the Bachman WTP



Elm Fork Water Treatment Plant

The Elm Fork WTP is located in the City of Carrollton, northwest of Dallas. Its raw water intake is also located on the Elm Fork of the Trinity River, just north of the Carrollton Dam, about 8 miles upstream of the Bachman WTP intake. The intake diverts water through pipelines to two low-lift pump stations where raw water is pumped to the treatment plant.

Figure 8-3 provides an aerial view of the Elm Fork facility. The plant is bound on all sides by existing development. However, a small plot of land remains vacant (owned by others) adjacent to the northeast plant boundary. DWU recently completed a 40-Year Facility Plan for the Elm Fork WTP that includes planning level concepts for implementation of the WQI Program while accommodating potential future expansion.

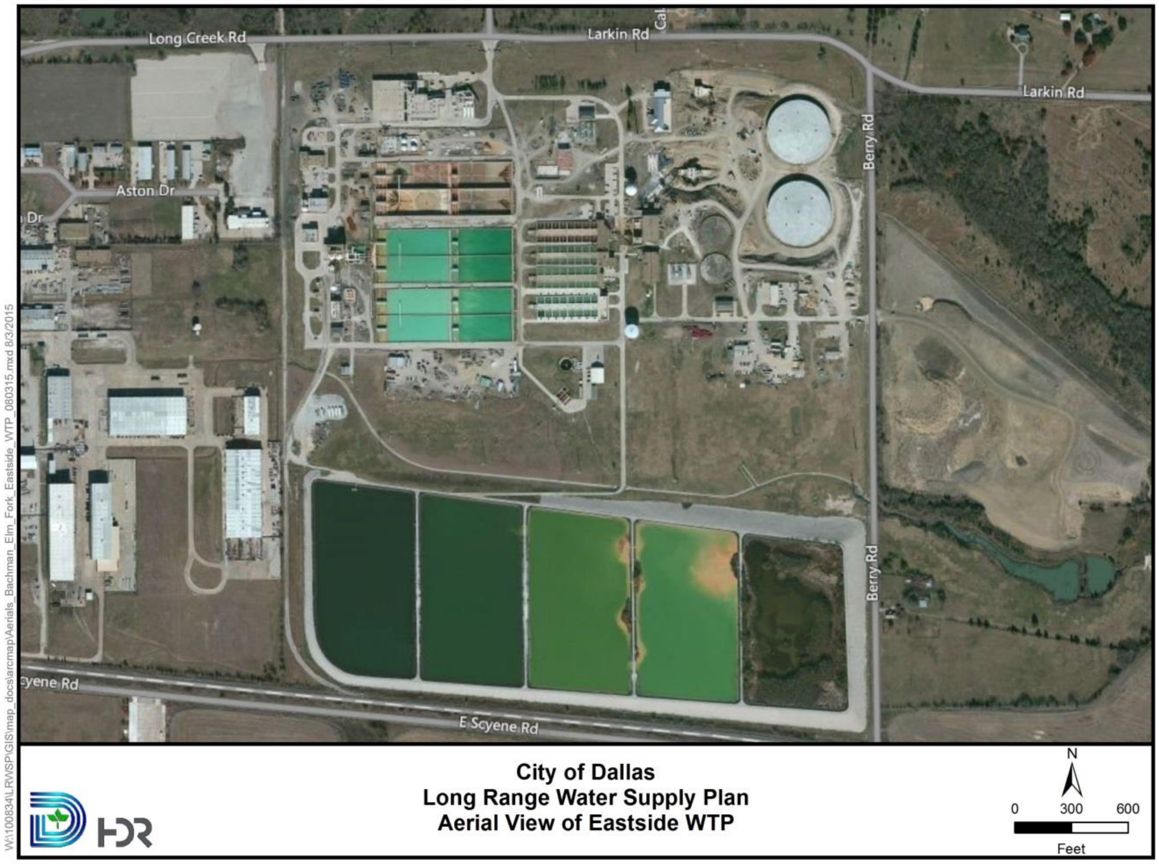
Figure 8-3. Aerial View of the Elm Fork WTP

Eastside Water Treatment Plant

The Eastside WTP is located in the City of Sunnyvale, east of Dallas. Figure 8-4 provides an aerial view of the Eastside facility. There is on-going construction at the plant to complete the WQI Program and the previously initiated expansion to 540 million gallons per day (MGD).

The Forney Pump Station pumps water from Lake Ray Hubbard directly to the treatment plant. The Iron Bridge Pump Station pumps water from Lake Tawakoni to the Tawakoni Balancing Reservoir where it then flows by gravity to the treatment plant. The Lake Fork Pump Station (recently placed in service) pumps water from Lake Fork to a pipeline interconnect near the Iron Bridge Pump Station and on to the Tawakoni Balancing Reservoir.

Figure 8-4. Aerial View of the Eastside WTP



8.2.2 Water Treatment Plant Service Customers

Service area boundaries of the three WTPs are considered approximate as they can shift, depending on demands and distribution system operating strategy, and at any given time water from any WTP could be serving any customer. 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 a number of 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 Eastside WTP typically serves most of the south, east, and northeast parts of Dallas as well as customer cities to the south and east.

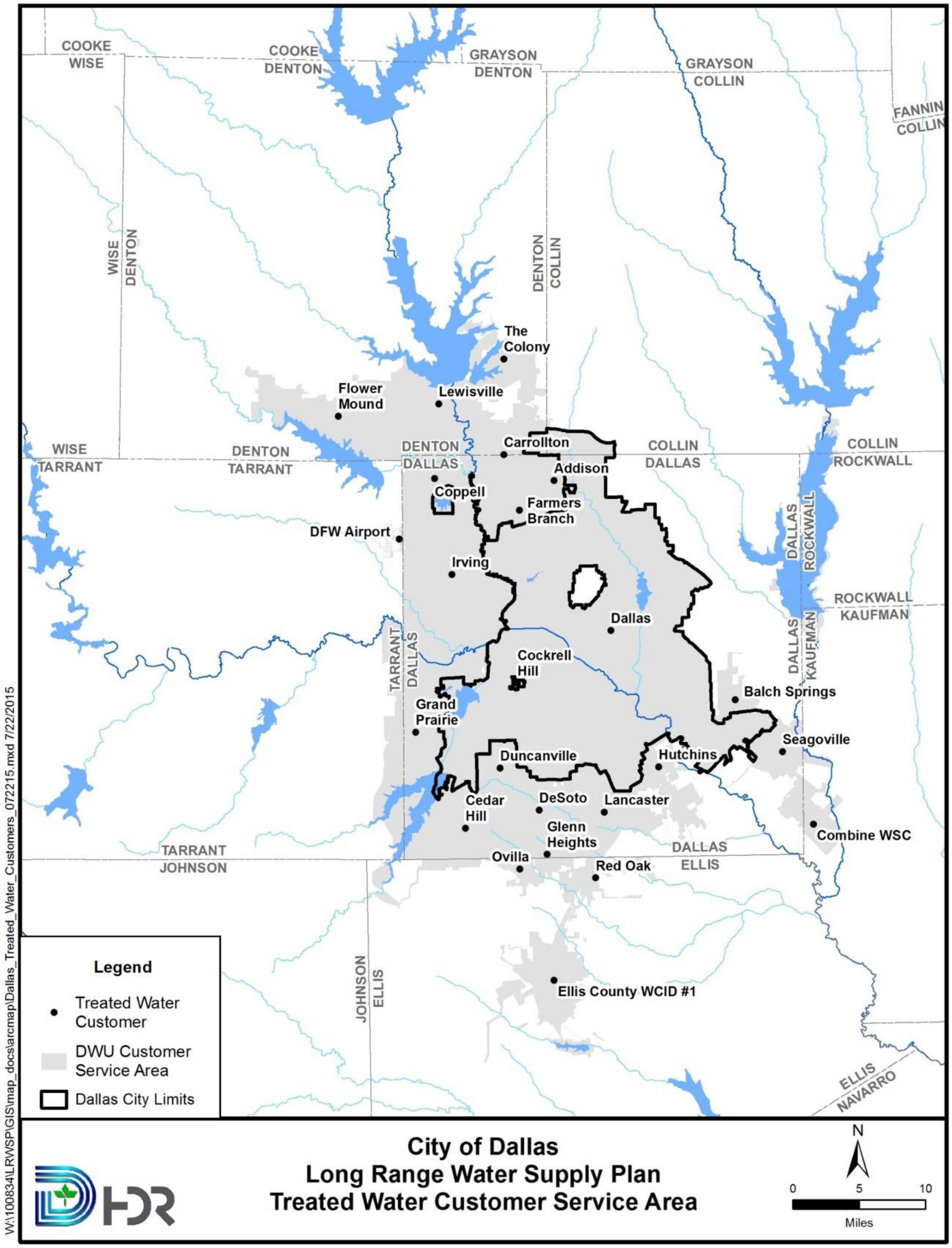
Treated Water Service Customers

Table 8-1 shows the current and projected (2070) treated water demand percentages for each customer. Figure 8-5 shows DWU's treated water service customers. As shown, the City of Dallas and manufacturing uses comprise about two-thirds of the treated water demand today and in the future.

Table 8-1. Dallas Treated Water Customer Contribution to Treated Water Demands

Entity	% of Approximated Current Treated Water Demand	% of Approximated Treated Water Demand in 2070
Dallas	59.3	61.70
Manufacturing Uses	6.29	5.57
Grand Prairie	5.46	5.12
Carrollton	5.08	3.48
Cedar Hill	2.26	2.60
Lancaster	1.64	2.31
Lewisville	0.26	2.19
DeSoto	2.03	2.08
Addison	1.29	1.78
Farmers Branch	1.95	1.77
Coppell	2.37	1.69
Flower Mound	1.85	1.32
The Colony	1.41	1.07
Duncanville	1.31	0.94
Irving	3.70	0.77
All other treated water customers	3.8	5.61

Figure 8-5. Area Served by Dallas and Its Treated Water Customers



Allocation of Treated Water Demands

Analysis performed during the 2014 LRWSP included an evaluation of Dallas' water demands by pressure plane within the Dallas retail system. Future treated water demands were distributed by pressure zone considering projected growth patterns extended to 2070. The distribution by pressure zone established that treated water demands will be split almost evenly between the Western and Eastern Supply Subsystems when excluding the City of Irving treated water demands. However, when Irving's treated water demands are considered (which occur on the Western Subsystem), this creates an approximate 55/45 percent split between the Western and Eastern supply subsystems. This 55/45 percent split is therefore used as the basis for assessing treatment capacity needs. Note: This is different than the 50/50 percent demand split based on Dallas demands discussed in Section 6, because Dallas is treating water for Irving that is supplied by Irving, not Dallas and therefore not part of Dallas' demand.

Operational Flexibility

The Dallas distribution system has the flexibility to shift the delivery of treated water between the three existing WTPs and each plant can deliver water to areas beyond its typical service area boundaries. Several factors may influence operating boundaries including individual, periodic treatment plant or facility shutdowns and capacity restrictions, water quality management, or the need to meet system pressures under specific operating constraints. A number of ground storage reservoirs and elevated storage tanks are located throughout the system with pumping stations to maintain and boost pressure in the various pressure planes. Five of the pumping stations also currently have booster chlorination facilities to boost disinfectant residual and maintain water quality.

As an example of system operating flexibility, a treatment process by-pass pipe was recently installed at the Elm Fork WTP to deliver water to the plant clearwells from the distribution system. This water (as transferred from the Eastside and Bachman WTPs) can then be delivered to the northwest portion of the service area using the Elm Fork WTP high service pump stations. These features provide added operational flexibility and afford Dallas the opportunity to remove treatment trains from service for annual cleaning and maintenance activities and for construction activities during low water demand periods.

To meet peak day or high water demand conditions, all three DWU plants must be operated and this currently presents some hydraulic limitations as noted in later sections.

8.2.3 Existing Water Treatment Plant Capacities

The rated production capacity is defined as the maximum treated water production when accounting for internal plant water use and waste streams. The reliable production capacity is the capacity at which each plant is considered operable for an extended period of time without limitation or increased risk of treatment or distribution issues as determined in previous Dallas evaluations (e.g. Elm Fork WTP Water Quality Improvements) and discussions with Dallas staff. Table 8-2 presents the existing, rated production capacity in MGD as compared to what is considered the current, reliable production capacity for each plant. The total rated production capacity is 1,000 MGD, whereas the reliable production capacity is approximately 910 MGD.

Table 8-2. Water Treatment Plant Rated and Reliable Production Capacities

Water Treatment Plant	Rated Production Capacity (MGD)	Reliable Production Capacity (MGD)
Bachman	150	130
Elm Fork	310	280
Eastside	540	500
Total	**1,000**	**910**

Source: Information provided by DWU treatment staff.

Each plant is capable of operating at its rated production capacity for limited periods of time. However, various factors limit this production time. At Bachman WTP, distribution system operating pressures in the vicinity of the treatment plant under various operating scenarios have led to typical maximum production rates being less than the rated production capacity. At Elm Fork WTP, lime dosing quantities used in the current lime softening process create hydraulic bottlenecks as lime scale builds and solids accumulate in the channels and basins. Higher process loading rates for the sedimentation basins and filters typically result in near continuous filter backwashing at rated production capacity. At the Eastside WTP, the existing four filter stages provide a total maximum capacity of 500 MGD at a re-established, lower design filter loading rate of 5 gallons per minute per square foot of filter area to coincide with planned biological filter operation.

The production capacity of each plant also depends on its high service pumping capacity. Table 8-3 builds upon Table 8-2 to show the existing high service pumping capacities at each plant.

Table 8-3. WTP Production and High Service Pumping Capacities

Water Treatment Plant	Rated Production Capacity (MGD)	Reliable Production Capacity (MGD)	High Service Pumping Capacity (MGD)	Minimum Limiting Capacity (MGD)
Bachman	150	130	150	130
Elm Fork	310	280	310	280
Eastside	540	500	440	440
Total	**1,000**	**910**	**900**	**850**

At the Eastside WTP, Transfer Pump Station 1 and 2 provide a pumping capacity of 440 MGD in conjunction with the Lake June and Jim Miller Pump Stations and pipelines. Transfer Pump Station 3 provides the additional capacity to coincide with the plant expansion to 540 MGD. However, there is currently no infrastructure in place to pump this expanded capacity to the distribution system.

Max Day Demand

The water supply demands presented in Section 4 are based on average day demand. However, Dallas' customers do not use a uniform volume of water everyday so "peaking" demand must be considered for adequate treatment plant capacity. Table 8-4 presents historical average and maximum (max) daily use data for 2000 through 2013. This table calculates a max day to average day ratio for each year. The maximum calculated ratio for these years is 1.71, which occurs twice in the data, once in 2000 and again in 2011. Since 2011 was a hot dry year, which tends to correlate to higher peak use, the 1.71 ratio was selected for use in the 2014 Dallas LRWSP to estimate future max day treatment demands.

Table 8-4. Dallas Historical Water Treatment Plant Production

Year	Max Day (MGD)	Date Max Day Occurred	Average Day (MGD)	Max to Avg Ratio [a]
2000	789.6	4-Sep	462.3	1.71
2001	734.4	10-Aug	450.2	1.63
2002	641.4	5-Aug	422.4	1.52
2003	692.2	7-Aug	423.5	1.63
2004	584.1	23-Jul	399.3	1.46
2005	621.3	27-Jun	437.2	1.42
2006	681.3	18-Aug	457.4	1.49
2007	574.8	27-Aug	386.2	1.49
2008	670.2	4-Aug	416.9	1.61
2009	625.7	16-Jul	389.8	1.61
2010	637.9	23-Aug	400.3	1.59
2011	682.6	8-Aug	398.3	1.71
2012	649.2	1-Aug	400.9	1.62
2013	582.7	8-Aug	376.9	1.55

Source: Dallas Water Utilities Data

[a] The maximum calculated ratio is 1.71, which occurs in 2000 and 2011. This is the ratio that was selected for use to estimate future max day treatment demands for Dallas.

Table 8-5 shows the estimated peak day treated water demand for the Dallas system (including the City of Irving treatment demand as Dallas treats Irving's supply). Comparing the last column of Table 8-5 to the minimum limiting capacity (850 MGD – Table 8-3) of Dallas WTPs indicates Dallas has sufficient overall plant capacity until the 2030 decade. However, there are other system limitations that Dallas must consider and these are presented in the following discussion.

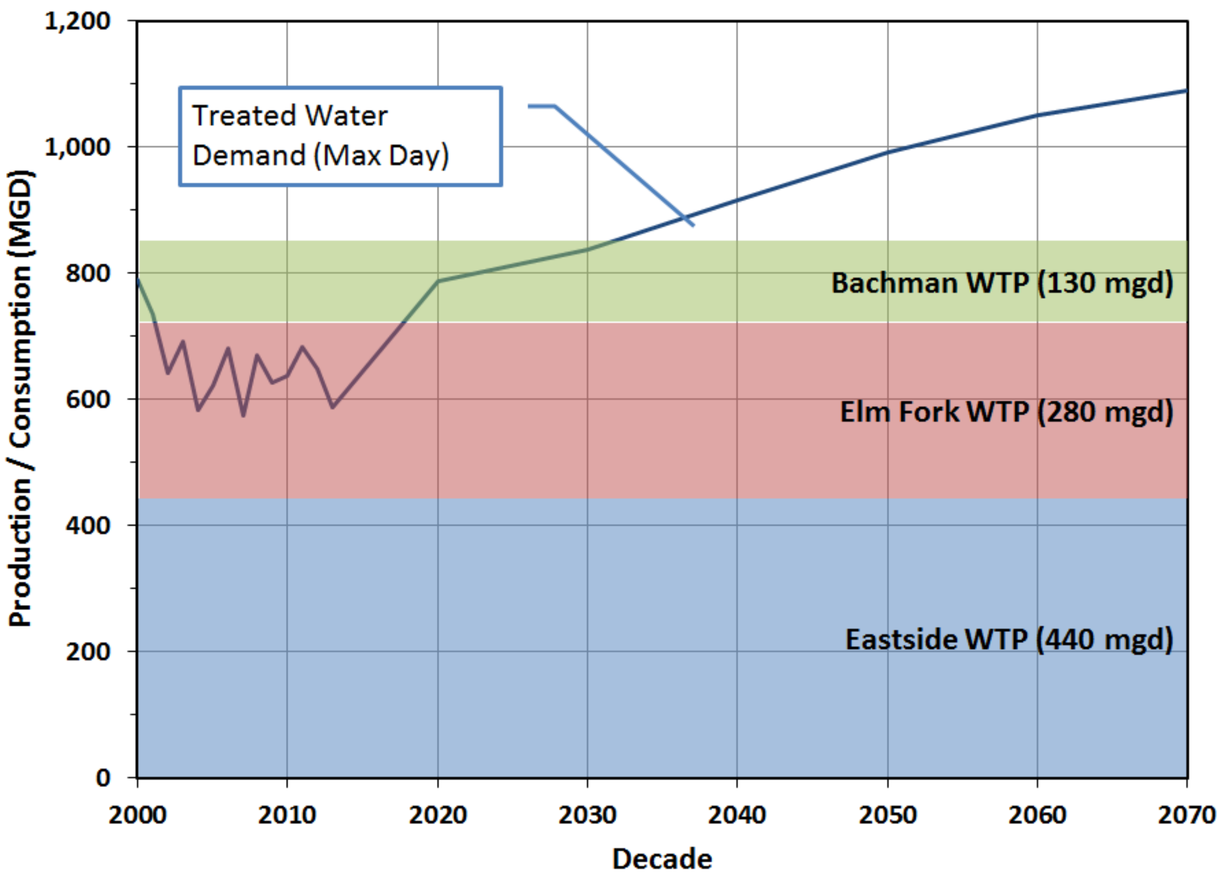
Table 8-5. Projected Dallas Max Day Demands

Year	Dallas Projected Treated Water Average Day Demands after Conservation (MGD)	City of Irving Average Treated Water Demand on Dallas (MGD)	Combined Total Average Day Demand (MGD)	Projected Max Day Demand (MGD) (Avg. Day X 1.71)
2020	396.8	53.5	450	770
2030	408.2	57.4	466	796
2040	442.5	57.0	500	854
2050	480.7	56.9	538	919
2060	512.3	56.9	569	973
2070	533.9	56.9	591	1,010

Source: Average Day Demands from Section 4, Table 4-12 minus conservation savings from Section 6, Table 6-5.

Figure 8-6 shows the existing limiting treatment capacity (850 MGD) relative to projected max day treated water demands considering the limiting production or pumping capacity values for each plant as shown in Table 8-3. Figure 8-6 indicates that Dallas is expected to exceed its 850 MGD combined peak day capacity by about 2033, or in about 20 years.

Figure 8-6. Existing Treatment Capacity vs. Projected Max Day Water Demands for DWU System



In-Plant Water Use, Recycle Flow, and Discharge Impacts on Capacity

Greater capacity is required in the treatment plants' upstream treatment process units considering the actual rated production capacity at each plant must account for in-plant treated water use. All three treatment plants currently use treated water to supply cooling water for the ozone generation process and carrier water for chemical feed. The treatment trains also generate residuals streams from sedimentation basin solids blow-down and spent filter backwash water. These water streams are either returned to the main treatment process flow or to residuals handling basins where decant is recycled back to the front of the treatment process.

Current in-plant water uses at the Dallas WTPs (collectively) include:

- Ozone system cooling water
- Lime system slaking water
- Polymer blend / carrier water
- Chlorine system
- Ammonia system
- Sedimentation basin solids blow-down
- Spent filter backwash water
- Filter-to-recycle
- Fluoride carrier water
- Orthophosphate carrier water
- Plant potable / service water

In-plant water losses and discharge streams also impart an additional water demand at the WTPs. Water losses can include leaks from treatment process infrastructure (i.e. basins, piping, flumes), losses related to plant potable water use such as irrigation, or water use for process analyzers and for sanitary purposes.

Upon a review of in-plant water use assumptions and data provided by each WTP, the ratio of rated production capacity to raw water flow required to produce that production capacity is greater than 0.99 at the Dallas WTPs (an apparent production efficiency of greater than 99 percent). This results from the high recovery efficiency of recycled water in the treatment process. At the same time, the in-plant water use requires the treatment process trains, from ozone contact through filtration, to be rated at a higher capacity than the plant's rated production capacity to produce treated water at the rated production capacity.

8.3 Future Water Treatment Plant Capacity Needs

This section presents water treatment capacity needs to meet projected maximum day treated water demands to the Year 2070. From an overall system perspective it is evident from Figure 8-6 that additional treatment capacity or infrastructure is needed by about 2034. If improvements were completed to fully achieve the permitted capacity, then additional capacity would likely not be needed till the 2050 decade. For the purposes of determining when and how much additional capacity is needed in the future, the Western Subsystem and Eastern Subsystem capacities are assessed separately, targeting a 55/45 percent split as previously discussed and the overall system is then viewed holistically to confirm total demands are met.

8.3.1 Western Subsystem WTP Capacity Needs

Figure 8-7 shows future treatment capacity needs for Dallas' Western Subsystem considering max day water demands to 2070. Treated water demands for the Western Subsystem are projected to exceed existing treatment capacity by about 2019.

As shown in Figure 8-7, incremental gains in treatment capacity can be achieved through implementation of currently planned infrastructure projects, namely the 72-inch diameter treated water pipeline and the Elm Fork WQI Program. Constructing the planned 72-inch diameter treated water pipeline to connect between the Elm Fork and Bachman WTPs (and beyond to the southwest) will increase reliable production capacity by removing system hydraulic limitations encountered at the Bachman WTP when the treatment plants are operating at maximum capacities. The Bachman WTP would then be able to achieve a reliable production capacity of 150 MGD.

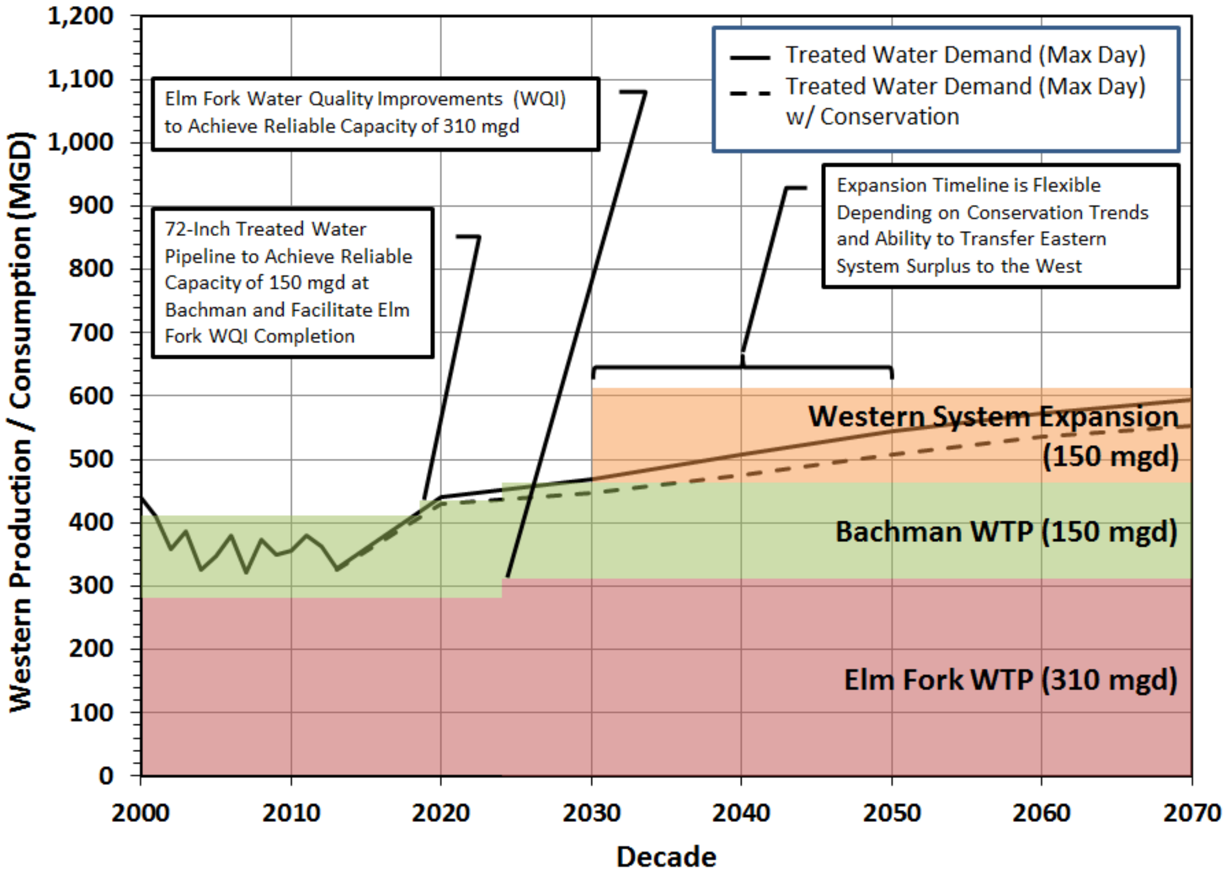
The 72-inch diameter line will also facilitate completion of the Elm Fork WQI by allowing extended shutdown times for construction. The line will allow greater flow to the Elm Fork WTP clearwells using the recently installed treatment process by-pass. Treatment process construction activities can continue while the by-pass is in operation and the Elm Fork WTP Pump Station 1 and 3 can continue to deliver water to the northwest service area. An objective of completing the Elm Fork WTP WQI Program is to increase the plant's reliable production capacity to 310 MGD while addressing water quality goals.

If these projects are completed as planned, the need for additional capacity in the Western Subsystem could be delayed to about 2030 as shown in Figure 8-7.

Western Subsystem WTP Expansion

A 150 MGD expansion of the Western Subsystem WTP capacity will eventually be required with the additional supply from the Main Stem Balancing Reservoir (MSBR). Implementation of the MSBR supply strategy is projected to occur by 2050. While Figure 8-7 shows additional treatment capacity will be needed by about 2030 to meet treated water demands, there is some flexibility in the timeline for a Western Subsystem WTP expansion if the on-going Eastside WTP expansion to 540 MGD and associated raw water conveyance system improvements are completed prior to this time. Resulting Eastern Supply surplus (see Section 8.3.2) and the potential impacts of conservation could allow Dallas to push an expansion closer to 2050, in-line with start-up of the MSBR supply.

Figure 8-7. Future Western Subsystem Treatment Capacity vs. Projected Max Day Demands

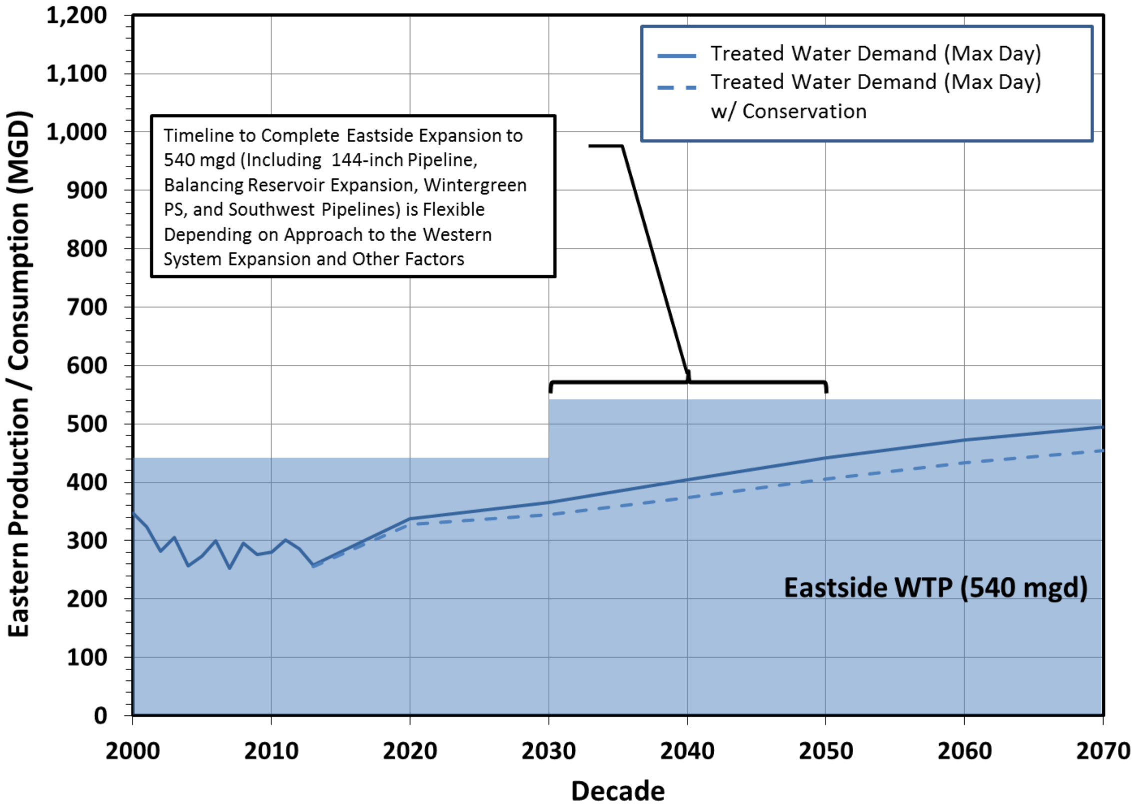


8.3.2 Eastern Subsystem WTP Capacity Needs

Figure 8-8 shows the future treatment capacity needs for Dallas' Eastern Subsystem considering max day water demands to 2070.

As shown, completion of the on-going Eastside WTP expansion to 540 MGD and associated treated water pumping and pipeline infrastructure is required by about 2050 based on max day demand projections. Alternatively, completing the Eastside WTP expansion by 2030 would provide DWU with some flexibility in delaying a Western Subsystem WTP expansion (per Figure 8-7) if treated water from the Eastside WTP is used to supplement treatment capacity in the Western Subsystem through increases in distribution infastructure.

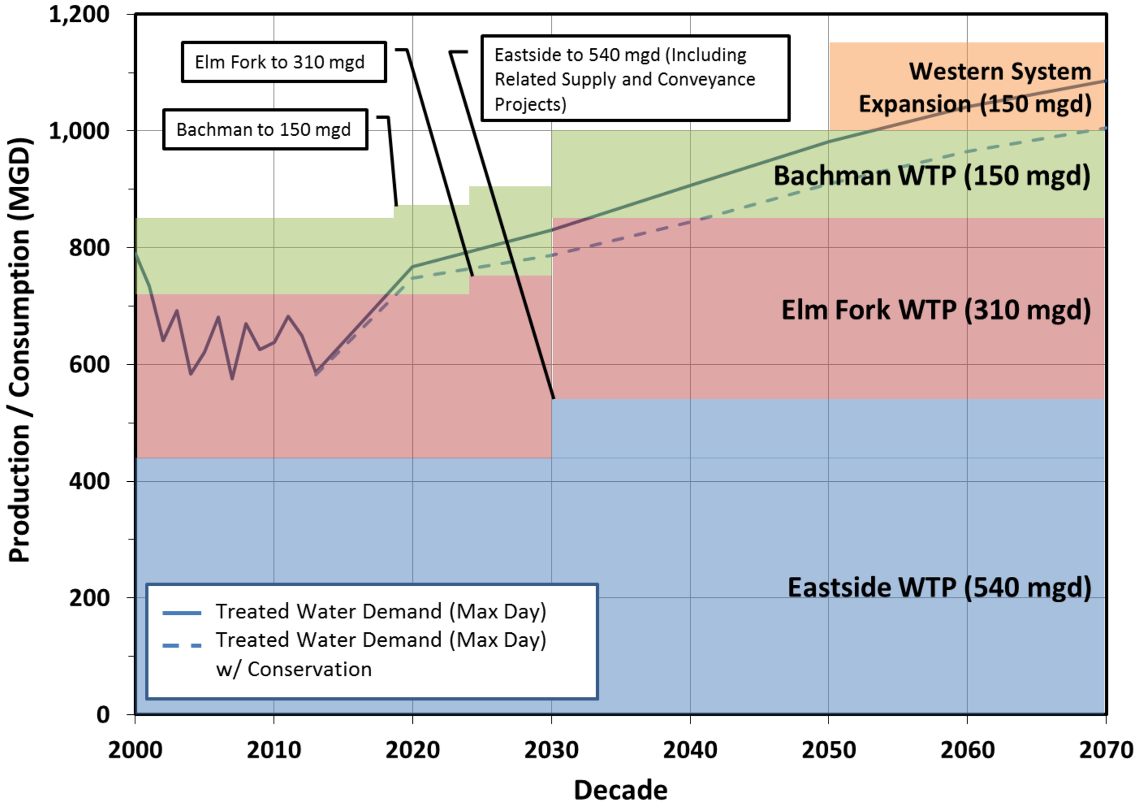
Figure 8-8. Future Eastern Subsystem Treatment Capacity vs. Projected Max Day Demands



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. As shown, the resulting combined capacity provides ample treated water system-wide and includes some management flexibility. For example, if a treatment process train at one of the WTPs fails or requires shutdown during maximum day demand conditions and water can be moved between the Western and Eastern subsystems, some buffer is available to allow shutdown while minimizing the risk of depleting available treated water. At the same time, if treated water demand follows the projections shown, excessive capacity would be minimized thereby reducing concerns for potential stranded capital investment.

Figure 8-9. Combined Treatment Capacity vs. Projected Max Day Demands



As indicated in Figure 8-7, Figure 8-8, and Figure 8-9, there is some flexibility in the timing of expansions provided the Eastern Subsystem surplus is used to temporarily offset the Western Subsystem deficit. Completion of the Eastside WTP expansion to 540 MGD and the Eastern Subsystem raw water conveyance improvements are shown to be completed by 2030. This seems reasonable considering improvements are underway at the Eastside WTP and the relatively low risk associated with the age and condition of the existing 72-inch and 84-inch diameter raw water pipelines from Lake Tawakoni which bring the supply to the Eastside WTP (refer to Section 8.4). Considering overall Eastern Supply Subsystem infrastructure reliability concerns, it is recommended Dallas continue with these projects.

8.4 Existing Raw Water Conveyance Systems

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 Dallas raw water conveyance system and its key components. The Dallas conveyance system is comprised of the Western Raw Water Supply Subsystem and the Eastern Raw Water Supply Subsystem.

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:

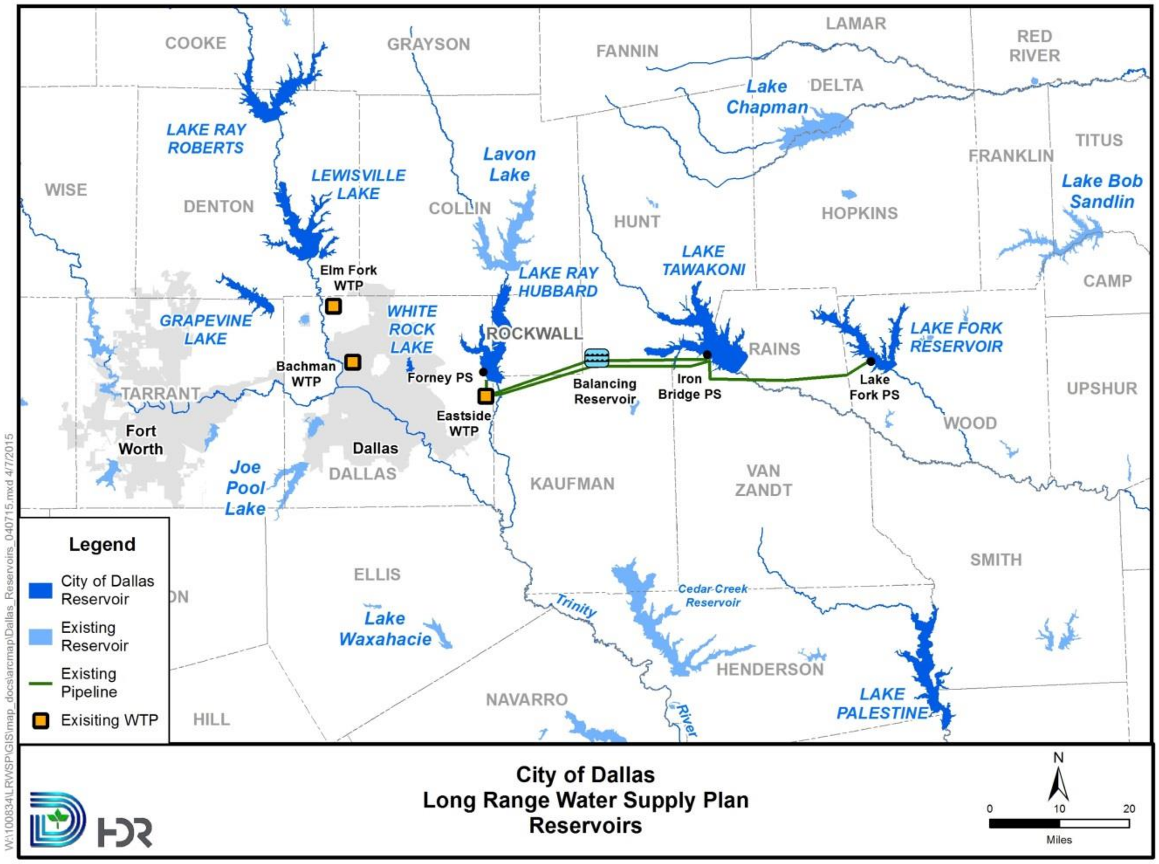
- Ray Roberts Lake – the furthest source to the north; water is released to the Elm Fork of the Trinity River where it flows into Lewisville Lake
- Lewisville Lake – water is released into the Elm Fork of the Trinity River below the Lewisville Lake Dam where it joins with Denton Creek and flows downstream 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 an intake and 96-inch pipeline to the WTP's Raw Water Pump Station

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 (recently placed in service) 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 8-6 provides a summary of the existing raw water pumping (or pipeline) capacities for the Western and Eastern Raw Water Supply Subsystems relative to the 2070 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 1.71 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 2070 supply of 2.6 meets the recommended ratio of 1.71 to meet peak day requirements. The ratio of current capacity to current supply (188.1 MGD) is about 2.6 and stay in that range assuming no change in capacity or available supply (considering projected return flows). Separately, the Elm Fork WTP and Bachman WTP conveyance subsystems provide a ratio well above 1.71.

Table 8-6. Raw Water Conveyance System Capacities Compared to 2070 Supplies

System Component	Pumping Capacity (MGD) [a]	Pipeline Capacity (MGD)	2070 Average Day Supply [b] (MGD)	Ratio of Capacity to 2070 Supply [c]
Western Subsystem Raw Water Conveyance				
Elm Fork WTP Supply and Raw Water Pumping	338	> 338	123.8	2.7
Bachman WTP Supply and Raw Water Pumping	160	> 160	66.7	2.4
Western Subsystem Total	**498**	**> 498**	**190.5**	**2.6**
Eastern Subsystem Raw Water Conveyance				
Lake Fork, Lake Fork Pump Station, and 108-inch Pipeline to the Tawakoni Interconnect	212	215	90.4	2.3
Lake Tawakoni, Iron Bridge Pump Station, and 72-inch / 84-inch Pipelines to Tawakoni Balancing Reservoir and on to Eastside WTP	230	215 [d]	226 [e]	0.95 [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, 2070 sediment conditions and 7 degree F increase in historical temperature.
[c] Should be greater than 1.71 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] Dallas currently has an amendment pending at TCEQ 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. Dallas has initiated 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 Eastside 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 2070 supply would increase from 0.95 to 1.96. It is noted the current ratio of capacity to supply is less than 0.95 considering the current supply available. While the current overall Eastern Subsystem ratio is about 1.6 (using a current yield (2020) of 314 MGD), the ratio will trend toward 1.9 and increase to 2.7 by 2070 assuming completion of the 144-inch diameter pipeline.

Limiting Factors

Table 8-7 presents a summary of raw water conveyance system total capacities from Table 8-6 compared to the existing WTP capacities and using current (2020) supplies.

Table 8-7. 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	188.1	338	> 338	280
Bachman WTP		160	> 160	130
Western Subsystem Total		498	> 498	410
Eastern Raw Water Conveyance and Treatment Subsystem				
Eastside WTP	314	752	515	440
Eastern Subsystem Total		752	515	440

[a] From Table 5-11.

Based on Table 8-6 and Table 8-7 and discussions in Section 8.3, the following near-term (within about the next 10 to 20 years) limiting factors are evident for the Western Raw Water Conveyance Subsystem:

- Limited Bachman WTP treated water pumping – due to operating pressures under certain distribution system operating conditions
- Limited Elm Fork WTP treated water production capacity – due to current treatment process limitations

Near-term limiting factors for the Eastern Raw Water Conveyance Subsystem include:

- Limited pipeline capacity from the Lake Fork / Lake Tawakoni interconnect to the Tawakoni Balancing reservoir – due to the 72-inch pipeline pressure limitation
- Limited treated water pumping capacity at the Eastside WTP
- Limited Eastside WTP capacity until current expansion is completed

8.5 Future Raw Water Conveyance System Capacity Needs

This section highlights raw water conveyance system capacity needs to meet projected water demands to 2070. In general, the raw water conveyance systems must be able to carry the required capacity to meet treated water demands as presented in Section 8.3 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 2070 along with recommended water supply strategies in relation to the average day water demands.

As shown, there is presently an existing water supply deficit in the Western Supply Subsystem during drought conditions. While 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. From the vantage point of the Western Supply Subsystem, the on-going Integrated Pipeline (IPL) Project to connect Lake Palestine should be constructed by 2027 to minimize the risk of future water supply shortages during drought conditions. The in service date for the addition of Lake Palestine (2027) considers the timeline needed to complete design and construction. 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 considering phased options as discussed in Section 7-5.

The supply surplus provided by implementation of the recommended strategies in 2060 and 2070 will serve to offset the supply deficit in the Eastern Supply Subsystem which begins about 2059 as shown in Figure 8-12.

8.5.2 Eastern Subsystem Raw Water Conveyance Capacity Needs

Figure 8-12 shows the projected Eastern Supply Subsystem firm water supply (based on 1950s drought) to 2070 along with recommended water supply strategies in relation to the average day water demands.

While there is an existing surplus in the Eastern Supply Subsystem until about 2059, the recommended water supply strategies include construction of the Main Stem Pump Station, while not needed by Dallas until the 2050 decade, it will likely be constructed by 2020 based on needs of the North Texas Municipal Water District (NTMWD). The surplus will offset the Western Supply Subsystem deficit until the IPL Project is completed. In about 2059, a supply deficit develops in the Eastern Supply Subsystem that will initially be offset by surplus in the Western Supply Subsystem.

While the Western Raw Water Conveyance Subsystem requires increased capacity through implementation of new, recommended water supply strategies, the Eastern Raw Water Conveyance Subsystem will require improvements to augment and increase reliability and redundancy for the existing supplies as noted in Section 8.4.2 while including improvements associated with the Main Stem Pump Station.

Figure 8-11. Projected Supply vs. Average Day Demands for DWU's Western Supply Subsystem

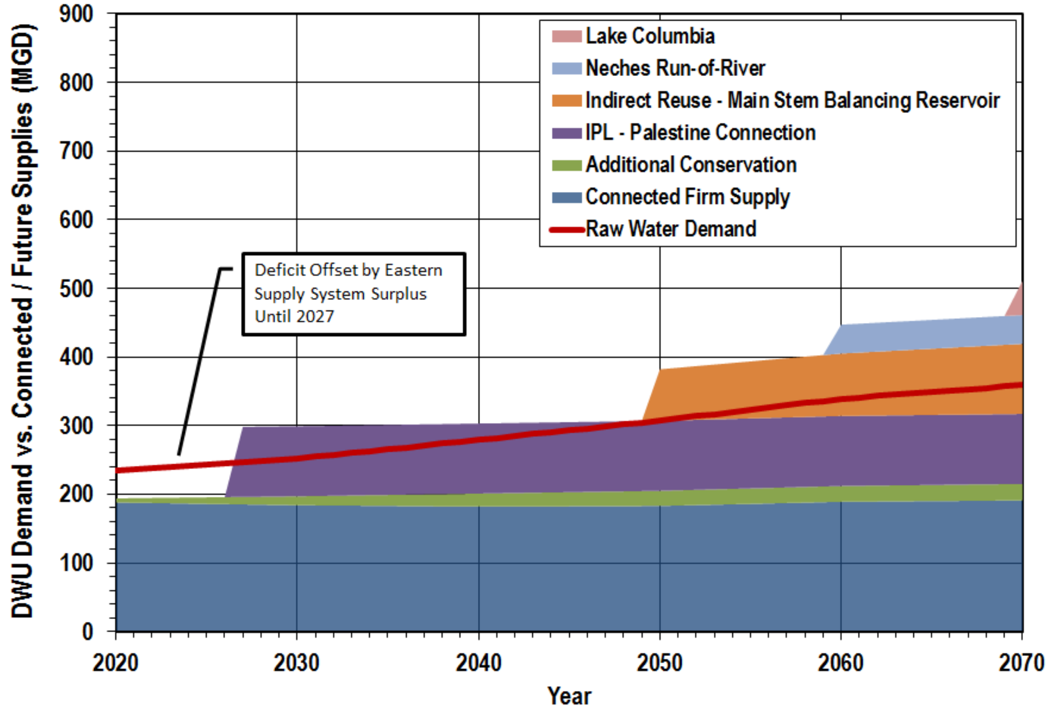
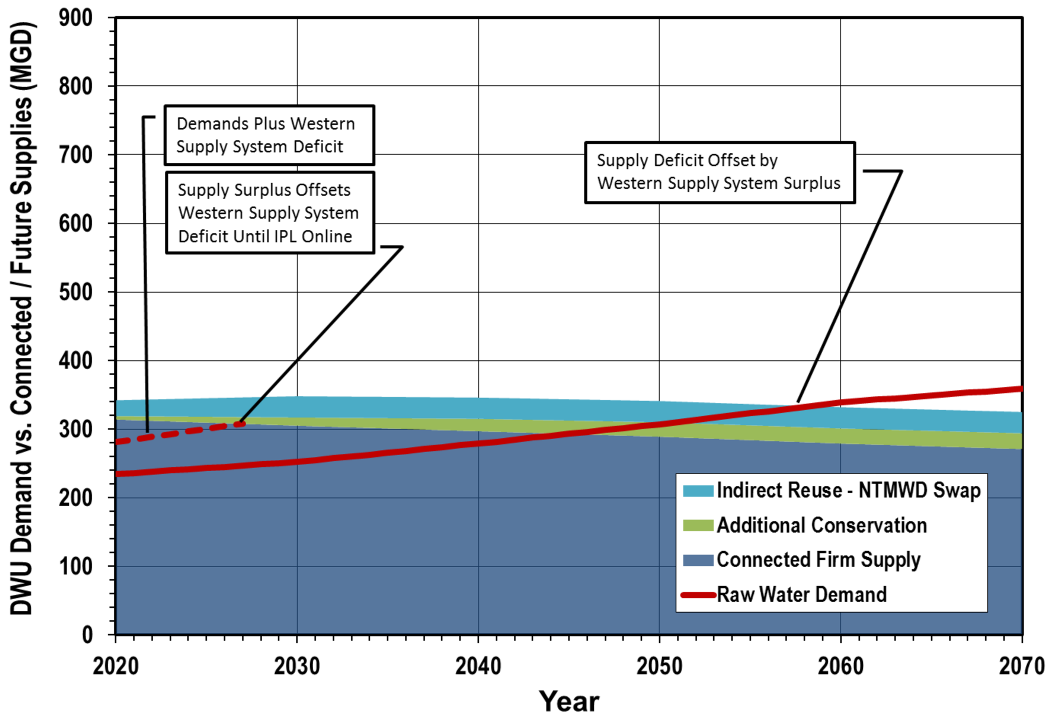


Figure 8-12. Projected Supply vs. Average Day Demands for DWU's Eastern Supply Subsystem



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:

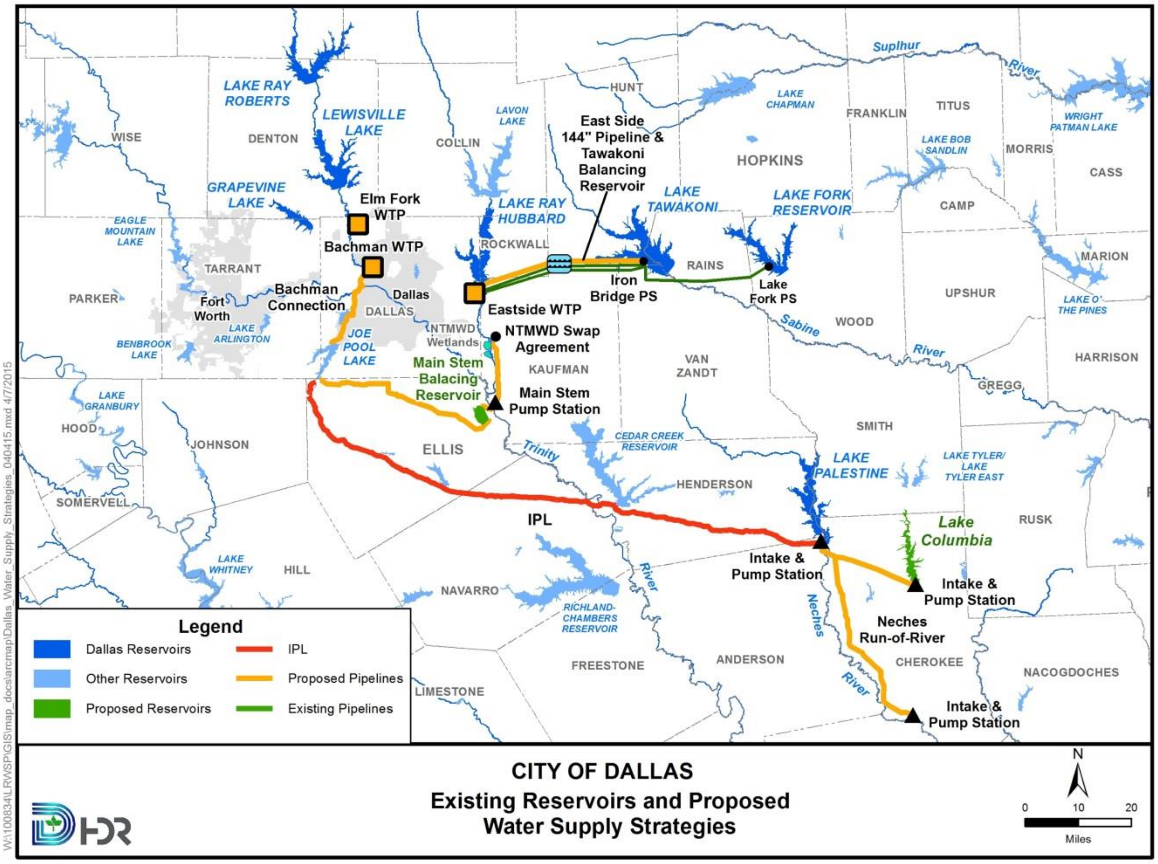
Western Supply Subsystem

- 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 102 MGD intake and pump station with 84-inch diameter transmission pipeline
- Conveyance of IPL water to the Bachman WTP area – includes alternatives with proposed gravity flow through Joe Pool Lake and Mountain Creek Lake and low head pump station as well as with pump station(s) and large diameter transmission pipeline(s); connection of the future MSBR supply may require parallel transmission pipelines depending on the selected approach
- Conveyance of IPL water to Western Subsystem WTP Expansion – includes pump station and large diameter transmission pipeline depending on location of the expansion
- Main Stem Pump Station and pipeline to the NTMWD wetlands – includes 90 MGD pump station, 14.2-mile 72-inch diameter transmission pipeline and channel dam
- Main Stem Balancing Reservoir – includes off-channel storage reservoir with sedimentation basin, 102 MGD intake and pump station with 72-inch diameter intake pipeline, and in-line transmission pump station(s) along a 36.5-mile 84-inch diameter transmission pipeline to the Joe Pool Lake area
- 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 and on to the Eastside WTP

Figure 8-13. Dallas Future Raw Water Conveyance System



8.6 Opportunities for Treatment and Distribution System Conservation

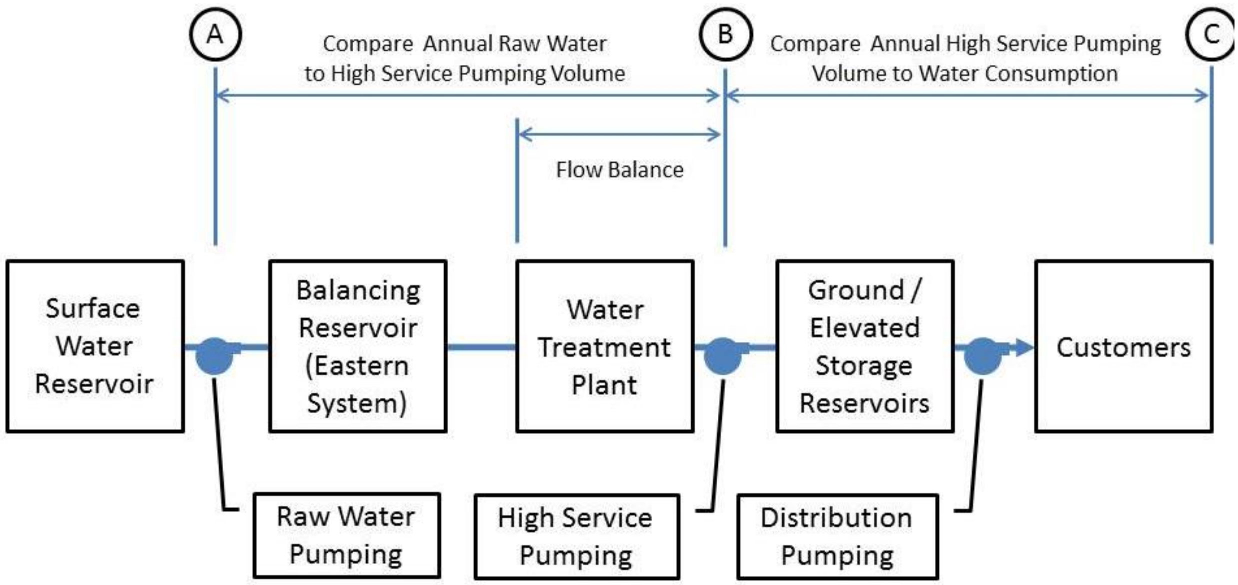
Dallas continues to implement and explore additional opportunities to conserve water. This section presents findings and conclusions from a review of raw water conveyance, treatment plant, and distribution system water uses, discharges, and unaccounted for water to identify additional opportunities to conserve and/or re-capture water supply. Potentially viable strategies and associated infrastructure improvements costs are provided and highlighted as emerging opportunities for further consideration.

Data provided by DWU included surface water use, unaccounted for water, high service pumping, pipe leak survey and detection program, in-plant water use, WTP discharge flows, and water loss data. The data were reviewed from the following perspective (also shown graphically in Figure 8-14):

- Raw Water Conveyance through Treatment – a comparison of annual raw surface water pumpage data to high service pumping volume.

- WTP Water Flow Balance Analysis (A to B) – in-plant water use, discharges, and water loss using water flow balances developed at each plants' current rated production capacity.
- High Service Pumping through Delivery (B to C) – a comparison of high service pumping volume to total consumption including DWU's unaccounted for water tracking data.

Figure 8-14. Approach to Water Production System Review



8.6.1 Findings and Conclusions: Raw Water Conveyance through Treatment (Point A to B)

Key findings and conclusions include:

- Over seven years of data, Dallas' average daily surface water use is 403.9 million gallons per day (MGD). The average high service pumping value is 401.4 MGD. The apparent difference, or unaccounted for water, is 2.5 MGD.
- On an annual basis, the 2.5 MGD difference translates to approximately 914 million gallons of unaccounted for water.
- The resulting average difference could be due to data accuracy and within typical expectations for flow metering.
- The resulting difference could be due to WTP water loss or discharge flows (within Point A to B) as noted in Section 8.6.3.
- Reducing water loss to zero is not probable considering leaks that will occur with aging infrastructure and a host of other factors (i.e. evaporation, changing soil conditions, effects of corrosion, etc.).
- Additional metering capability would facilitate completing more intensive, periodic water audits. Tracking and trending the flow data collectively, at all metering points from water intake through treatment, and for all water uses between, can provide

additional information to further refine estimates of production efficiency and unaccounted for water.

- DWU invests approximately $1.8 million per year (from the November 2011 DWU briefing on water conservation) in a pipe leak detection and survey program that includes survey of the raw water conveyance systems; continuing this program at an increased frequency can help DWU find and address leaking infrastructure.

8.6.2 Findings and Conclusions: Water Treatment Plants (within Point A to B)

Key findings and conclusions include:

- DWU is already practicing a high level of conservation at each of the WTPs through the capture and recycle of spent filter backwash, filter-to-recycle, and sedimentation blow-down.
- A number of in-plant water demands are necessary for operation. While additional metering can facilitate potential optimization and the overall cost of treatment, adjustments to these flows do not impact production efficiency. The flows are returned to the process.
- Based on in-plant water use data and assumptions provided by each WTP, there is a known, apparent water loss of approximately 2.7 MGD at maximum capacity, or about 1.47 MGD at average operating conditions.
- Each WTP holds a Texas Pollutant Discharge Elimination System (TPDES) permit to discharge flows from its respective residuals lagoons within permit limitations. On-going and potential future improvements may impact discharge flows. These flows could be re-claimed as water supply or captured, treated and returned to the treatment process.
- Addressing identified issues, such as the Elm Fork WTP lime building drain and eliminating the flushing water demand, will result in a water savings.
- While not readily quantifiable, infrastructure leaks are likely present at water holding structures (i.e. flumes, basins, piping, clearwells, pump station wetwells / suction flumes). The Eastside WTP and, more recently, the Elm Fork WTP experienced sedimentation basin floor slab failures. It is difficult to determine leakage rates if leaks are present. At Elm Fork, the difference between the raw water flow meter readings and individual filter effluent flow meters can be as much as 20 MGD in either direction. If a fraction of this difference, 5 MGD for example, can be attributed to leaks, a more significant water loss results than that indicated by the 2.7 MGD of quantifiable discharges / water loss.
- Reducing water loss to zero is not probable considering leaks that will occur at basin joints and as infrastructure continues to age. Additional metering, monitoring tools, and targeted inspection can assist with identifying and quantifying leaks. Implementing pipe leak detection technology for the large diameter piping on a periodic basis can also help detect issues early (every two to three years).

8.6.3 Findings and Conclusions: High Service Pumping through Delivery (Point B to C)

Key findings and conclusions include:

- Unaccounted for water shows a downward trend with less than 8 percent unaccounted for water in fiscal year 2014. This is below the Dallas goal of less than 10 percent. These trends suggest that on-going programs and efforts are making a difference in managing system water loss.
- Leak detection programs are required by Texas Administrative Code (TAC) Title 30, Chapter 288 and Dallas' proactive pipe replacement, flushing, and leak / survey detection programs ensure that DWU complies with these requirements. Flushing water use is the primary water use that continues to trend upward. Flushing continues to be necessary to maintain distribution system water quality. Strategic flushing, the use of auto-flushers and tools such as an operational model can serve to further reduce flushing water use. An operational model can assist with identifying potential operational adjustments that can improve water age (and quality) as well as capital improvements that may help to address issues.
- The Water Quality Improvements at the WTPs are targeted to improve distribution system water quality. These improvements are in construction at the Eastside WTP, are beginning construction at the Bachman WTP, and are in preliminary design at the Elm Fork WTP. It is expected that system flushing water use (from hydrants) will begin to decrease upon completion of these improvements.
- The recently initiated pipeline corrosion study is expected to provide additional long-term benefit.

8.6.4 Continuing Efforts to Reduce System Water Loss

Figure 8-15 summarizes DWU water use from 2008 through 2014. Figure 8-16 plots the same data as shown in Figure 8-15. However, the data are not stacked and are fit with linear, best-fit lines to highlight trending.

The leak detection and repair program goals include surveying the entire distribution system once every 2.5 years. Since 2004, DWU has proactively surveyed over 15,000 linear miles of pipe for leaks. The program also includes leak detection and survey for the raw water conveyance pipelines. In 2012 and 2013, the leak detection program surveyed more than 4,000 miles of pipeline. In 2014, a total of 417 leaks were found over 4,692 miles of pipe (one leak for every 11.25 miles). Using leak rates established by DWU, it is estimated that the potential water savings ranged from 1.2 to 4.8 billion gallons assuming leaks may go undetected for as much as 6 to 24 months.

Figure 8-15. DWU Water Use Considering Unbilled and Unaccounted for Water (2008 through 2014)

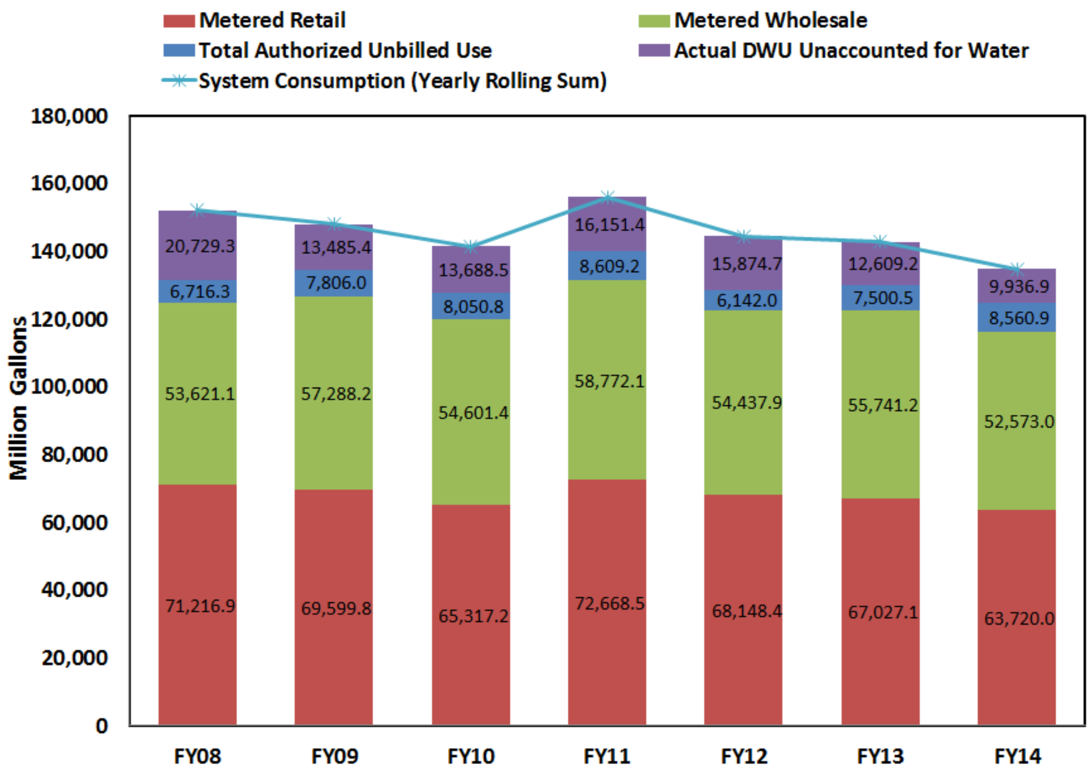
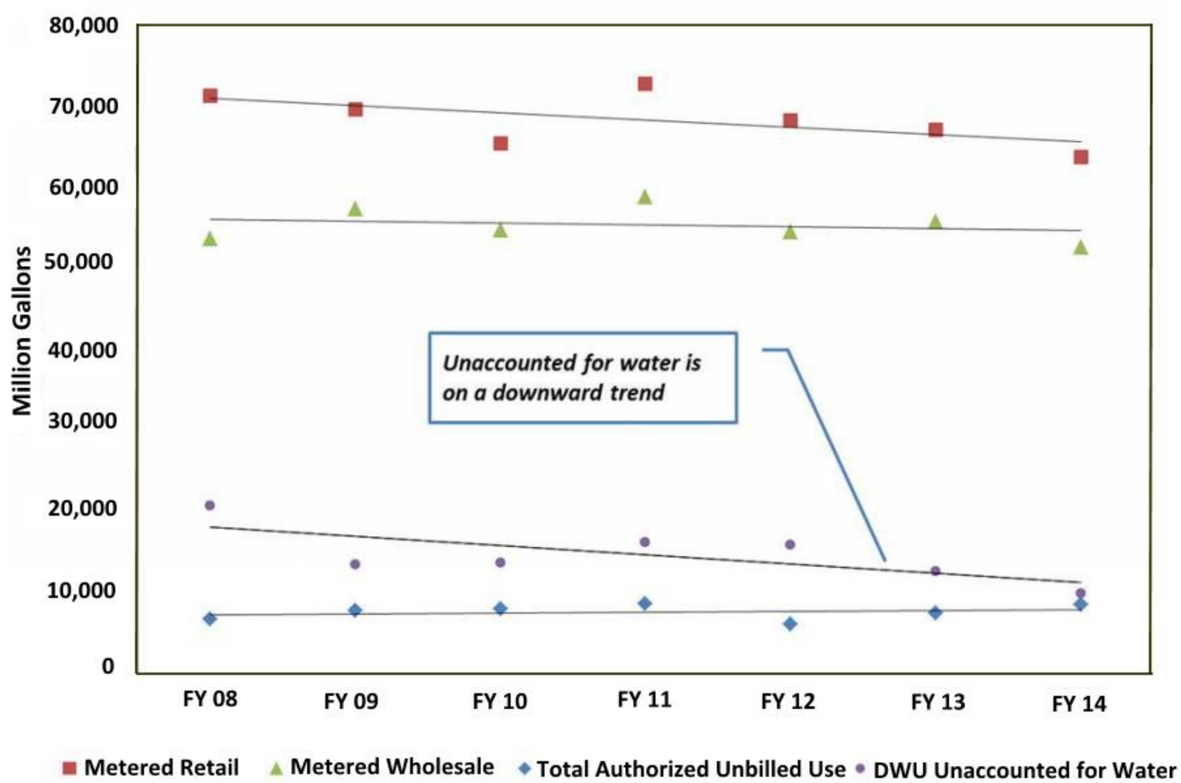


Figure 8-16. DWU Water Use Trends Considering Unbilled and Unaccounted for Water (2008 through 2014)



In addition to ongoing leak detection, repair, and proactive pipe replacement programs, there are currently planned water supply and treatment infrastructure projects that include potential water conservation opportunities. Table 8-6 provides examples of planned projects and the potential impact with respect to conservation opportunities. The dash in the table under the status column represents that some items occur as needed and do not necessarily require significant planning and design efforts.

Table 8-8. Ongoing or Currently Planned Projects that Include Water Conservation Opportunities

Project	Status	Water Production Efficiency / Conservation Impact
Western Raw Water Supply and Treatment Subsystem		
Bachman WTP *Water Quality Improvements*	Construction	Can provide flow metering improvements and address structure rehabilitation; targeted to improve distribution water quality (decrease rate of pipe corrosion and reduce flushing water use)
Elm Fork WTP *Pre-sedimentation Basin*	Bid (on hold)	Can reduce the amount of turbidity in the water entering the treatment plant; leads to a decrease in chemical use and less residuals generated at the treatment plant requiring blow-down
Elm Fork WTP *Residuals Handling Improvements*	Design	Addresses water quality objectives while managing discharge flows
Elm Fork WTP *Water Quality Improvements*	Planning / Preliminary Design	Can provide flow metering improvements and address structure rehabilitation; targeted to improve distribution water quality (decrease rate of pipe corrosion and reduce flushing water use)
WTP Major Maintenance Projects	-	Can address items such as the lime building drain and rehabilitation of structures, crack repair, etc.
Eastern Raw Water Supply and Treatment Subsystem		
Eastside WTP *Water Quality Improvements*	Planning / Preliminary Design / Design & Construction	Can provide flow metering improvements and address structure rehabilitation; targeted to improve distribution water quality (decrease rate of pipe corrosion and reduce flushing water use)
Eastside WTP *Residuals Basins and Sludge PS Improvements*	Planning	Can address water quality objectives while managing discharge flows
WTP Major Maintenance Projects	-	Can address items such as the lime building drain and rehabilitation of structures, crack repair, etc.

8.6.5 Emerging Treatment and Distribution System Conservation Strategies

Upon review of the Dallas water production system for additional conservation opportunities, the following potential strategies (and improvements) were identified:

- Address lime building drain at the Elm Fork WTP
- Capture residuals lagoon discharge at all three WTPs and re-claim as supply
- Convert landscape areas to xeriscape
- Capture WTP drain flows (analyzer flows, seal flush water, sample tap discharges, etc.)
- Implement rainwater harvesting for irrigation
- Implement Stage 2 Treatment (treatment of spent filter backwash water and thickener / residuals basin decant for return to clearwells) at the WTPs as an alternate approach to expand capacity and manage in-plant recycle and residuals basin discharge flows
- Cover treatment train basins to reduce water loss due to evaporation
- Capture flush water in the distribution system and couple with rainwater harvesting for irrigation
- Capture storage tank overflows using overflow basins

Table 8-7 presents these potential strategies and includes noted benefits as well as any potential undesired outcomes or risks of pursuing a given item. Planning level costs are also shown with a "value factor". The "value factor" in this case is a planning level quantification of the potential value of water savings realized from implementing a given strategy divided by the estimated cost for implementation (a cost-benefit factor). The value of water savings is based on the estimated average water cost for developing new sources of supply per Table 6-2 of the 2014 LRWSP Report ($2 per 1,000 gallons) and an approximated treated water cost ($0.70 per 1,000 gallons). For comparison purpose, the overall cost of service for retail customers (FY 2014 -15 – 2015 Budget) is $3.98 / 1000 gallons. The strategies (opportunities) in the matrix are sorted from highest to lowest potential value and are categorized as Tier 1, Tier 2, or Tier 3 as follows:

- Tier 1 – Value Factor greater than 0.5
- Tier 2 – Value Factor between 0.25 and 0.5
- Tier 3 – Value Factor less than 0.25

Table 8-9. Treatment and Distribution System Conservation Strategies

Strategy (Opportunity)	Water Production Efficiency / Conservation Benefit and Risk	Planning Level Cost ($)	Approx. Water Savings (MGD)	Approx. Value of Savings ($M)	Value Factor
Tier 1 Strategies					
Address Lime Building Drain	*Benefits: capture true water loss* *Risk: resolution of lime building drainage and potential clogging (new pipe clogs again)*	$1 M	1.2	$0.9 M	0.9
Capture Lagoon Discharge[1]	*Benefits: capture true water loss and re-claim as supply* *Risk: permitting and process to claim water rights*	$6.2 M	6.3	$4.6 M	0.7
Convert Landscape Areas to Xeriscape	*Benefits: reduces plant water demand for irrigation* *Risk: does not meet local landscape ordinances*	$0.3 M	0.3	$0.2 M	0.7
Tier 2 Strategies					
Capture Drain Flows (analyzer flows, seal flush, sample taps, etc.)	*Benefits: capture true water loss* *Risk: separate collection and pumping system likely required; increased maintenance*	$0.8 M	0.4	$0.3 M	0.4
Rainwater Harvest for Irrigation	*Benefits: reduces plant water demand for irrigation* *Risk: requires increased maintenance for system; rainfall may not provide adequate volume*	$0.8 M	0.3	$0.2 M	0.3
Stage 2 Treatment	*Benefits: negates recycle stream and need to treat water twice; addresses water quality; provides expanded capacity* *Risk: capital intensive; requires more detailed life-cycle cost analysis and understanding to weigh cost-benefit of implementation*	$100 M	30	$27.3 M[2]	0.3

Table 8-9. Treatment and Distribution System Conservation Strategies (Cont.)

Strategy (Opportunity)	Water Production Efficiency / Conservation Benefit and Risk	Planning Level Cost ($)	Approx. Water Savings (MGD)	Approx. Value of Savings ($M)	Value Factor
Tier 3 Strategies					
Cover Basins (Basins Only, not Lagoons)[3]	*Benefits:* reduces water loss from solar evaporation *Risk:* does not address evapotranspiration from wind and humidity effects	$10.7 M	0.1	$0.07 M	<<0.1
Flushing and Rainwater Harvesting for Irrigation[4]	*Benefits:* captures true water loss *Risk:* creates additional remote items requiring maintenance for small margin of potential gain	$2 M	0.1	$0.07 M	<< 0.1
Capture Tank Overflow Using Overflow Basin / Use for Site Irrigation[4]	*Benefits:* captures true water loss *Risk:* capital intensive	$10 M	1.0	$1 M	0.1

1 This item reflects annual water cost versus annual water savings. Thus, the value factor as prescribed here is not a comparison of an annual savings versus one time capital cost as with the other strategies shown.
2 Based on an assumption that water is discharged as a water loss if not treated using Stage 2 treatment.
3 Lagoon covers to minimize evaporation not considered practical.
4 Assumed for installation at 10 sites.

The Tier 3 strategies are shown are not considered viable from a cost-benefit perspective. However, Dallas may want to consider further review of the Tier 1 and Tier 2 strategies as emerging opportunities for applicability to and inclusion in Dallas' Water Conservation Strategic Plan. As an example, next steps may include a detailed, comparative life-cycle evaluation of re-capturing WTP discharge flows as supply versus continuing recycle practices or capturing discharges for treatment.

8.7 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.

8.7.1 On-going and Previously Planned Improvements

Table 8-10 provides a summary of previously planned water supply and treatment infrastructure projects (from Dallas' 2012 Capital Improvements Program, or CIP) with noted benefits / significance to the Dallas system.

Table 8-10. Currently Planned Water Supply and Treatment Infrastructure Projects (from 2012 CIP)

Project	Status	Benefits / Significance
Western Raw Water Supply and Treatment Subsystem		
IPL Project *Connect Lake Palestine*	Design	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.
Bachman WTP *Conversion to Enhanced Coagulation with Biofiltration*	Construction	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.
Elm Fork WTP *Residuals Handling Improvements*	Design	Provides needed additional residuals basin volume for solids processing; addresses improvements at the existing basin site and removal of over-accumulated solids; and frees up site space at the Elm Fork WTP for Water Quality Improvements and potential future expansion.
Elm Fork WTP *Pre-sedimentation Basin*	Bid (on hold)	Dampens raw water quality spikes that complicate treatment; enhances incoming water quality to Elm Fork WTP with projected savings in ozone and chemical costs; reduces solids produced at the plant for processing at the residuals basins.
Elm Fork WTP *Pump Station 1*	Design	Addresses aging equipment and suction hydraulics issues (pumps dating to 1950s); allows adjustment of capacities to re-align raw water and high service pumping within context of needed capacities.
Elm Fork WTP *Rapid Mix / Flumes / East Chemicals*	Planning / Preliminary 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 the plant's full rated production capacity of 310 MGD.
Elm Fork WTP *Biological Filters*		
Elm Fork WTP *Floc-Sed Basin Improvements*		
Elm Fork WTP *West Chemicals*		

Table 8-10. Currently Planned Water Supply and Treatment Infrastructure Projects (from 2012 CIP) (Cont.)

Project	Status	Benefits / Significance
72-inch Treated Water Pipeline *Bachman WTP to Elm Fork WTP*	Design	Facilitates transfer of treated water in the western subsystem; relieves hydraulic challenges in Bachman service area for more reliable production at the rated production capacity of 150 MGD; addresses reliability concerns for the existing pipeline; will facilitate future Elm Fork project construction with increased by-pass flow to the Elm Fork clearwells – water can be pumped to distribution while the treatment process is shut down for phased construction improvements.
Eastern Raw Water Supply and Treatment Subsystem		
Iron Bridge Pump Station *Rehabilitation*	Design (on hold)	Upgrades aging facility with new equipment for reliable pumping; pumping units to be sized for current and future flow conditions considering the planned 144-inch pipeline.
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to Eastside WTP*	Design	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 Eastside 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 *Expansion*	Design (on hold)	Provides 1 day of storage for expanded 540 MGD Eastside subsystem; addresses rehabilitation needs and increase in capacity coinciding with pump station and pipeline improvements.
Eastside WTP *Electrical Distribution System Improvements and Substation 3*	Design (substation by Oncor)	Upgrades electrical system to meet peak requirements at the expanded plant capacity of 540 MGD; increases reliability and robustness.
Eastside WTP *Filter-to-Waste / Hydraulic Improvements / Filter Media*	Design	Optimizes enhanced coagulation and biofiltration performance; basin modifications target required overflow rates to improve settled water quality and downstream filter performance; engineered biofiltration chemical systems, filter-to-waste, filter media change to granular activated carbon (GAC), and backwash improvements optimize biological filter performance; post-clearwell ammonia feed provides additional capability to achieve stable chloramines residual.
Eastside WTP *Non-chloraminated Backwash Pump Station*	Design	
Eastside WTP *Sedimentation Basin Modifications*	Design	
Eastside WTP *Post-Clearwell Ammonia Feed and Engineered Biofiltration*	Planning / Preliminary Design	
Eastside WTP *Stage V Filters*	Design	Completes the Eastside WTP expansion to 540 MGD within desired filter loading rates for implementation of biological filtration.
Eastside WTP *Residuals Basins and Sludge PS Improvements*	Planning	Addresses full basins and restores basin capacity; separates sedimentation basin blow-down solids from spent filter backwash to improve plant recycle water quality.

Table 8-10. Currently Planned Water Supply and Treatment Infrastructure Projects (from 2012 CIP) (Cont.)

Project	Status	Benefits / Significance
Wintergreen Pump Station	Planning	Increases pumping capacity from Eastside WTP to 540 MGD to match treatment capacity; provides transfer of treated water into the southwest portion of the system for additional flexibility in meeting demand.
Southwest Pipelines	Planning	

As exhibited in Table 8-10, Dallas has already put in motion a number of projects that will position the City for meeting future water supply and treatment needs. Other potential projects under consideration that are not listed include Stage 2 treatment of spent filter backwash and / or residuals basin decant water at each WTP. Stage 2 treatment can provide an additional approach to expanding treatment process train capacity.

8.7.2 Required Improvements and Associated Project Drivers

Additional water supplies and treatment capacity will be needed between now and 2070 and the goal of balancing the Western and Eastern Supply Subsystems creates some potential shifts in infrastructure needs and prioritization. Table 8-11 presents the projects noted in Table 8-10 with the addition of infrastructure improvement programs associated with newly identified water supply and treatment capacity needs. Projects in Table 8-10 that are already in construction are not shown in Table 8-11. 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. When capacity needs can be met by multiple, different projects, projects that address multiple drivers are given precedence. For example, completion of the Eastside WTP expansion to 540 MGD, associated raw water conveyance, and treated water pumping are given priority over an expansion of the Western treatment capacity. A majority of the Eastside expansion has been completed and completion of the program addresses multiple drivers including system reliability and related risk. The IPL Project is shown as a higher priority considering its overall impact on reducing the risk of potential water supply shortages and increasing overall system water supply flexibility.

While a small number of projects shown are related to high service pumping and distribution system transmission mains, the scope of the 2014 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 operations staff. A more comprehensive water treatment facility plan and update to the distribution system master plan are recommended to identify and re-fine planning in coordination with the 2014 LRWSP. The future approach to a Western Subsystem WTP expansion can also then be defined in the context of understanding both supply and distribution system planning while accounting for typical operational requirements and distribution system water quality drivers.

Table 8-11. Summary of Future Water Supply Strategies and Treatment Infrastructure Projects

Project	Drivers	Start By [a]	Complete By [a]	Capital Cost [b]
Target Projects for Completion by 2020				
Elm Fork WTP *Pre-sedimentation Basin*	G / R	Q1 2015	Q3 2017	$30 M
Elm Fork WTP *Residuals Handling Improvements*	G / R / M	Q3 2015	Q2 2018	$95 M
Eastside WTP *Water Quality Improvements* [c]	G / R / M	Q4 2015	Q3 2018[d]	$75 M
72-inch Treated Water Pipeline *Bachman WTP to Elm Fork WTP*	G / R / M	Q4 2015	Q3 2018	$57 M
Elm Fork WTP *Pump Station 1*	R / M	Q1 2016	Q2 2018	$35 M
Main Stem Pump Station / Pipeline to NTMWD Wetlands	G	Q1 2017	Q1 2020	$18 M
2020 Target Projects Total				***$310 M***
Target Projects for Completion by 2025				
Iron Bridge Pump Station *Rehabilitation*	R / M	Q4 2019	Q1 2022	$47 M [e]
Eastside WTP *Residuals Basins and Sludge PS Improvements*	M	Q1 2018	Q1 2022	$95 M
Elm Fork WTP *Water Quality Improvements* [f]	G / R / M	Q4 2018	Q1 2024	$240 M
2025 Target Projects Total				***$382 M***
Target Projects for Completion by 2030				
IPL Project *Connect Lake Palestine*	G	On-going	Q1 2027	$1,097 M [g]
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to Eastside WTP*	G / M	Q1 2026	Q1 2030	$420 M

Table 8-11. Summary of Future Water Supply Strategies and Treatment Infrastructure Projects (Cont.)

Project	Drivers	Start By [a]	Complete By [a]	Capital Cost [b]
Wintergreen Pump Station and Southwest Pipelines	G	Q1 2026	Q1 2030	$310 M
Tawakoni Balancing Reservoir Expansion	G / M	Q1 2027	Q1 2030	$66 M
Eastside WTP *Electrical Distribution System Improvements and Substation 3*	G / M	Q4 2027	Q1 2030	$18 M
Eastside WTP *Stage V Filters*	G / R	Q4 2027	Q1 2030	$40 M
2030 Target Projects Total				***$1,951 M***
Target Projects for Completion by 2035				
Stage 2 Spent Filter Backwash Treatment at WTPs	G / R	Q1 2031	Q1 2035	$112 M [h]
Target Projects for Completion by 2050				
Main Stem Balancing Reservoir (DWU) Pump Station / Pipeline	G	Q1 2040	Q1 2050	$434 M [i]
Western WTP Expansion	G	Q1 2046	Q1 2050	$405 M [j]
2050 Target Projects Total				***$839 M***
Target Projects for Completion by 2060				
Neches Run-of-the-River	G	Q1 2050	Q1 2060	$160 M
Target Projects for Completion by 2070				
Lake Columbia	G	Q1 2060	Q1 2070	$160 M
50-Year Target Projects Total				***$3,914 M***

[a] Start and finish of construction; based on an understanding of inter-relating projects and sequencing through discussions with DWU staff and WQI program components.
[b] Capital costs are for construction only and are based on costs reflected in the Dallas 2014 CIP unless otherwise noted.
[c] Eastside WTP WQI projects remaining include the non-chlorinated backwash pump station, post-clearwell ammonia feed, chemical feed water softening, and engineered biofiltration chemical systems ($30M per 2014 CIP) and filter-to-waste / hydraulic improvements with media replacement ($45M per 2014 CIP); process conversion to biofiltration is on-going and sedimentation basin modifications were awarded for construction in 2014 and therefore are not shown.
[d] The Dallas 2014 CIP indicates filter-to-waste / hydraulic improvements with media replacement ($45M) in Fiscal Year 20-21; the change to GAC media is an additional optimization step for biofiltration and can be completed in parallel with other projects.
[e] Based on latest HDR Engineering, Inc. opinion of probable construction cost.
[f] Elm Fork WTP WQI includes rapid mix, flumes, east chemicals, biological filters, floc-sed basins, and west chemicals assumed as one project; costs based on recent understanding of projected WQI program costs
[g] Total Capital Cost includes Elm Fork expansion and transmission improvement costs .
[h] Based on $35M for Elm Fork WTP from previous DWU study; $17M for Bachman WTP and $60M for Eastside WTP based on capacity ratio relative to Elm Fork WTP.
[i] See Section 7-6: includes delivery to Joe Pool reservoir, but not to a Dallas treatment plant.
[j] See Section 7-5.

8.7.3 Implementation Timeline

Figure 8-17 presents the proposed water supply and treatment infrastructure implementation timeline based on the needs as identified and prioritized in Table 8-11. Individual projects are not depicted, but are grouped with milestones to coincide with the listing of improvements.

Risk if Projects are Delayed or Not Implemented

Table 8-12 notes the associated risk(s) if a given project is delayed or not implemented under the assumption that projected water supply and treated water demands increase as predicted.

Figure 8-17. Water Supply and Treatment Infrastructure Implementation Timeline

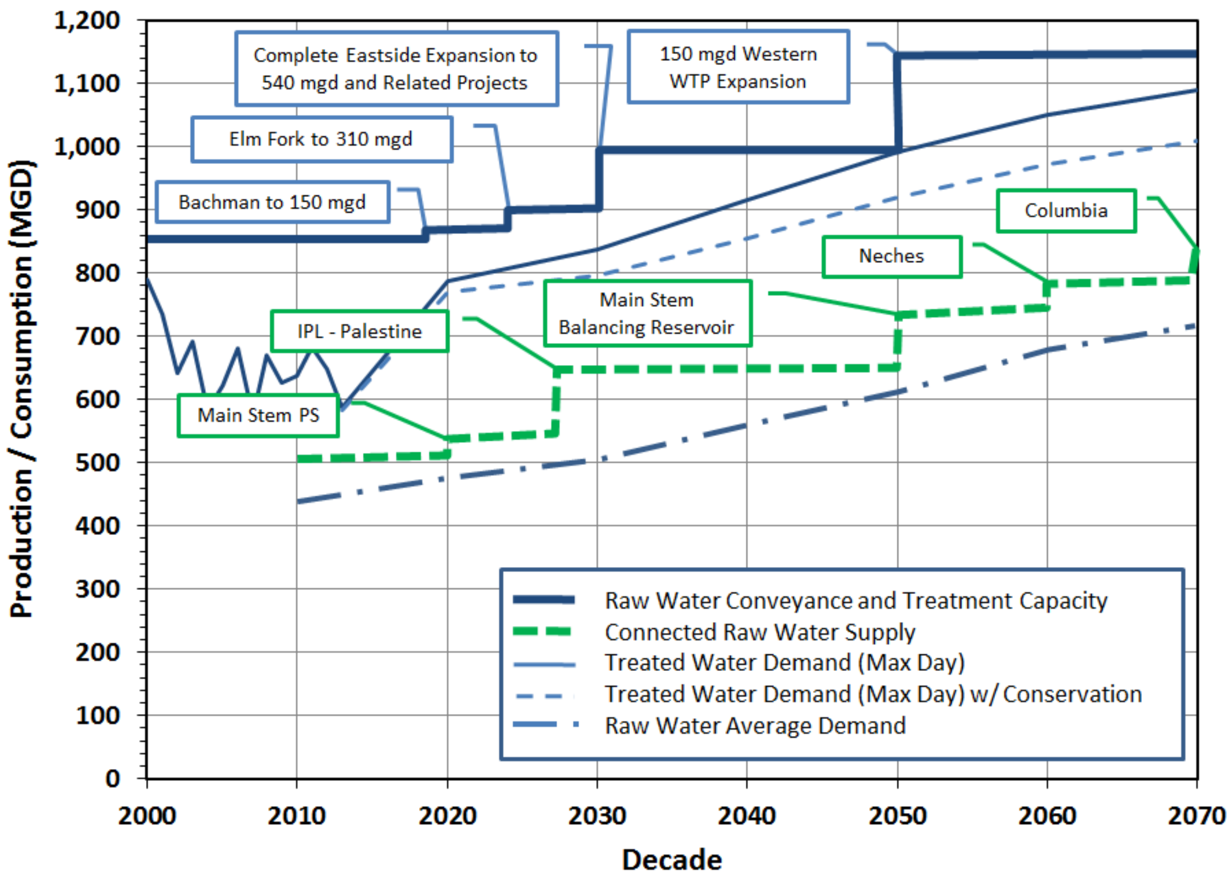


Table 8-12. Project Risk if Delayed or Not Implemented

Project	Drivers	Risk if Delayed or Not Implemented
Elm Fork WTP *Pre-sedimentation Basin*	G / R	Continued treatment response challenges; may require increase in needed Elm Fork WTP process facilities and equipment for residuals handling improvements (or less than optimum performance if facilities are not adjusted); will not recognize potential reduction in use of coagulant and liquid oxygen (for ozone generation) due to decreased ozone demand.
Eastside WTP *Water Quality Improvements*	G / R / M	Without adjustment of flocculation-sedimentation basin hydraulic retention time and surface overflow rates, there will be more frequent filter backwashing (with potential for reduced net filter production) due to higher settled water turbidity; less than optimum biological filter performance in targeting stable finished water in the distribution system without implementation of non-chloraminated backwash.
72-inch Treated Water Pipeline *Bachman WTP to Elm Fork WTP*	G / R / M	Continued hydraulic challenges in the distribution system with increasing reliability concerns for the existing pipeline; increased potential for construction outages or schedule protraction to complete Elm Fork WTP improvements.
Elm Fork WTP *Residuals Handling Improvements*	G / R / M	Continued just-in-time solids removal that can limit water production; site space not available at Elm Fork WTP to accomplish planned improvements.
Elm Fork WTP *Pump Station 1*	R / M	Increasing risk of failure; failure rate has increased over the last several years; reduces reliability of Elm Fork WTP capacity.
Iron Bridge Pump Station *Rehabilitation*	R / M	Equipment is aging (1950s and 1960s); have experienced past electrical and equipment failures; increased probability of failure - impacts delivery of water from Lake Tawakoni and potentially Lake Fork.
Eastside WTP *Residuals Basins and Sludge PS Improvements*	M	Basins will reach full capacity within the next 10 years; residuals processing impacts treatment operation and water production; current recycle water quality can have negative impacts on treatment.
Elm Fork WTP *Water Quality Improvements*	G / R / M	Continued water quality challenges in the distribution system; limited reliable production capacity of approximately 280 MGD due to process and hydraulic limitations.
IPL Project *Connect Lake Palestine*	G	Increased potential for water supply shortages due to water supply deficit during times of drought in the Western Supply Subsystem.
144-in Pipeline *Tawakoni Interconnect to Balancing Reservoir and on to Eastside WTP*	G / M	Existing 84-inch pipeline has experienced multiple failures and is not dependable and 72-inch design pressures limit capacity; a failure of the existing pipelines would severely limit the eastern supply; without operational changes, increasing risk of system water shortages.
Wintergreen Pump Station and Southwest Pipelines	G	Eastside production remains limited at 440 MGD despite expansion of supply and treatment infrastructure to 540 MGD capability.

Table 8-12. Project Risk if Delayed or Not Implemented (Cont.)

Project	Drivers	Risk if Delayed or Not Implemented
Tawakoni Balancing Reservoir *Expansion*	G / M	Increasing risk of embankment failure and dam safety issues; limits storage capacity available to Eastside WTP if east reservoirs / pumping are temporarily out of service.
Eastside WTP *Electrical Distribution System Improvements and Substation 3*	G / M	Increasing risk of failure(s); system has become less reliable and power supply is not adequate for peak requirements at 540 MGD.
Eastside WTP *Stage V Filters*	G / R	Would require a variance to operate filters at a higher loading rate at 540 MGD capacity; potential for decreased filter performance and need for increased backwash frequency due to increased head loss accumulation rate with biological filtration - results in lower net production.
Stage 2 Spent Filter Backwash Treatment at WTPs	G / R	Treated Water Quality Study objective is to separate streams and ultimately eliminate in-plant recycle of streams that can negatively impact treatment and resulting finished water quality.
Western Subsystem WTP *Expansion*	G	Not enough treatment capacity to meet future demands.
Main Stem Pump Station / Pipeline	G	Increased potential for water supply shortages for both Dallas and NTMWD.
Main Stem Balancing Reservoir (DWU) Pump Station / Pipeline	G	Increased potential for water supply shortages.
Neches Run-of-the-River	G	Increased potential for water supply shortages.
Lake Columbia	G	Increased potential for water supply shortages for Dallas and local project sponsors.

8.7.4 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.

Conclusions

- Current, combined water treatment reliable production capacity is about 850 MGD considering current treatment and high service pumping limitations.
- Treated water demands will exceed an 850 MGD combined peak day capacity by about 2034, or in about 20 years.
- Completing previously planned projects in the Western Subsystem over next several years can address limiting factors and increase 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 prior to 2027 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.
- The potential for additional water conservation may allow further delay of water treatment capacity expansions.

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 a number of 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 holistic approach to integrated, system-wide planning:

- Continue with planned projects per Table 8-11 including:
  - Water Quality Improvements Programs,
  - Main Stem Pump Station and Pipeline to the NTMWD wetlands by 2020,
  - Bachman WTP and Elm Fork WTP improvements that will achieve reliable production capacities of 150 MGD and 310 MGD, respectively, within the next 5 to 10 years,
  - IPL Project (parts 1 and 2) completed by 2027,
  - Eastside WTP Expansion to 540 MGD with associated raw water conveyance system and high service pumping and pipeline improvements by 2030,
  - Western Subsystem WTP expansion and Main Stem Balancing Reservoir, Pump Station, and Pipeline by 2050,
  - Neches Run-of-the-River infrastructure by 2060,
  - And Lake Columbia infrastructure by 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 Section 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.

9 Conclusions and Recommendations

9.1 Summary

Dallas initiated the 2014 LRWSP effort in 2012 with the goal of identifying, evaluating, and selecting water management strategies to meet future water supply needs for Dallas and its customers. Dallas has identified six (6) recommended water management strategies that meet this goal. These recommended strategies rely heavily on conservation and reuse supplemented by the development of new supplies by partnering with other water supply entities. This section provides a summary of the findings and conclusions, recommendations, and next steps for Dallas to consider in the implementation of the 2014 LRWSP.

9.2 Findings and Conclusions

Findings and conclusions from the analysis and evaluations performed during the development of the 2014 LRWSP include the following:

- Dallas' service area is defined by the area served by its existing customers, both treated and untreated. For example, Dallas provides water to entities that serve Denton County, but Dallas' service area is not all of Denton County.
- In 2020, the City of Dallas population is projected to be 1,242,135 and by 2070 Dallas' population is projected to increase to 1,905,498 which is an increase of 663,363 or 53.4 percent.
- In 2020, the total population of Dallas and its customer cities is projected to be 3,062,874, and by 2070 this population is projected to increase to 5,335,956 which is an increase of 2,273,082 or 74.2 percent.
- Between 2020 and 2070 Dallas' existing supplies are expected to decrease from 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.
- 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.
- Additional raw water supply provided by Lake Palestine through the IPL project is needed prior to 2027 to minimize the risk of water supply shortages during droughts.
- Combined reliable water treatment capacity is currently about 850 MGD considering treatment and high service pumping limitations.
- Treated water peak day demands are expected to exceed Dallas' reliable water treatment capacity of 850 MGD by about 2034, or in about 20 years.
- Completing previously planned projects in the western subsystem over the next several years will address factors limiting water treatment capacity needed to meet

near term needs and will push the need for treatment capacity expansion to the 2050 decade.

- Dallas has selected six (6) recommended and seven (7) alternative strategies to meet future water supply demands to 2070 and beyond.
- Addressing reliability concerns and expansion in the eastern subsystem by implementing previously planned projects can satisfy capacity needs and if completed prior to about 2030, could allow for the delay of a western subsystem WTP expansion or major infrastructure projects.
- 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 2014 LRWSP allows Dallas to keep about a 15 percent supply buffer over the estimated demands.
- Throughout the 2014 LRWSP, Dallas has coordinated with Region C so that the two plans are consistent and Dallas' results from the 2014 LRWSP can be incorporated into the 2016 Region C plan.
- Dallas should move forward with the recommendations provided in this section to implement recommended strategies.

9.3 Recommendations

The following is a list of recommendations, or next steps, that Dallas should move forward with to implement the findings of the 2014 LRWSP. These recommendations are separated into three groups. The first group includes additional studies that are needed to provide Dallas additional information prior to Dallas 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 2014 LRWSP and are recommended for Dallas's consideration:

- Dallas should initiate a Main Stem Balancing Reservoir permitting and feasibility study that includes:
  - securing the water rights permit for the storage reservoir and amend Dallas' existing reuse permit instream flow requirements,
  - performing a reservoir site foundation (geotechnical) evaluation,
  - preparing a water quality evaluation of the reservoir,
  - performing a siting study for the main-stem balancing reservoir pump station considering bank stabilization, water level control and flooding issues;

   - 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 and TRWD should re-evaluate the planned 150 MGD capacity of the two Palestine to Cedar Creek segment of the IPL considering that the combined supply from the three recommended strategies could supply as much as 194 MGD [i.e. Lake Palestine (102 MGD), Neches Run-of-the-River (42 MGD) and Lake Columbia (50 MGD)]. Once the delivery capacity is finalized, Dallas and TRWD should proceed with the final design of the Palestine to Cedar Creek segment of the IPL. An evaluation of the shared segments of the IPL should be performed to identify what upgrades may be needed to deliver future additional supply through this pipeline.
- Dallas should initiate a follow-on study to the 2014 LRWSP that results in identifying critical infrastructure components and associated implementation phasing needed to fully integrate the recommended strategies that together will supply 296 MGD of new supply to Dallas' western subsystem. This includes supplies from Lake Palestine (102 MGD), the Main Stem Balancing Reservoir (102 MGD), Neches Run-of-the-River (42 MGD), and Lake Columbia (50 MGD). This study would consider alternative delivery routes considering a combination of pipelines and natural stream systems, potential use of Joe Pool Lake storage or other facilities for meeting balancing needs and water quality and blending issues. This study would consider and include:
   - Coordination with TRA and other stakeholders regarding the potential use of Joe Pool Lake as part of the delivery system for the IPL water considering water quality and blending issues.
   - Development of a Western Subsystem Water Treatment Master Plan which considers the implications of implementing the recommended water supply strategies and associated treatment plant and distribution system improvements.
- 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 chosen by Dallas as part of the 2014 LRWSP, 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.
- Partner with the ANRA on the permitting of Lake Columbia including the 404 permitting process and the amendment of ANRA's existing water right to include an interbasin transfer which would authorize Dallas' use of this water in the Trinity River Basin.
- Dallas should continue to pursue potential new customers for direct non-potable reuse in the identified reuse corridor.

- Dallas in cooperation with other regional partners should initiate a feasibility study of the Red River 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 with other regional partners for the conjunctive use of Carrizo-Wilcox groundwater and diversions of Sabine River water to an OCR.
- Dallas should discuss the potential interest with all major water providers in the North Texas Metroplex area to consider a study to evaluate the benefits and problems of operating all or portions of the region's water supply sources as a single system or subsystems, instead of multiple separate systems.

9.3.2 Permitting

Dallas should immediately proceed with several permitting efforts identified in the 2014 LRWSP given the complexity of the current regulatory and permitting system for water rights permits. Suggested permitting activities include:

- Dallas should seek an amendment to the Ray Roberts and Lewisville permits that allow for downstream diversion of the existing authorized diversion at the Main Stem Balancing Reservoir site. This would not be a request for new state water, but a request to move some of the existing diversion downstream.
- Dallas should seek an amendment to the return flows permit to remove all or a portion of the 114,000 acft/yr instream flow restriction and have it replaced with the newly adopted Senate Bill 3 environmental flow standards for the Trinity River Basin.
- Dallas should seek the required 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 seek authorization to use the bed and banks of the East Fork and Main Stem of the Trinity River to release water from Lake Ray Hubbard (and possibly the Tawakoni Pipeline) for subsequent diversion at the Main Stem Balancing Reservoir for use in the western subsystem to allow for greater flexibility in system operations.

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.

- Continue discussions with USACE on the required maintenance for USACE owned Dallas supply reservoirs. Implement a long-term maintenance plan to provide for continued use of these resources.
- Continue to coordinate with NTMWD on the implementation of Main Stem Pump Station swap Agreement strategy.
- Consider negotiations with Oklahoma and/or the USACE for access to additional water in Lake Texoma to supply a potential desalination strategy.
- Continue with planned projects discussed in Section 8, including:
  - Water Quality Improvements Programs,
  - Bachman WTP and Elm Fork WTP improvements needed to achieve reliable treatment capacities of 150 MGD and 310 MGD within the next 5 to 10 years,
  - Eastside WTP Expansion to 540 MGD with associated high service pumping and pipeline improvements by 2030,
  - Eastside raw water conveyance improvements including construction of the 144 inch diameter pipeline from Lake Tawakoni by 2030, and
  - Western subsystem WTP expansion or new Southwest WTP by 2050.

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List of Appendices

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Appendix A

TWDB Population Methodology

(Obtained from https://www.twdb.texas.gov/waterplanning/data/projections/methodology/index.asp)

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Projection Methodology – Draft Population and Municipal Water Demands

1 Table of Contents

2 Population

The population projection methodology takes place in two steps: first, projections at the county level and then projections at the city/utility level.

2.1.1 County Population Projections

Draft county population projections are based on Texas State Data Center (TSDC)/ Office of the State Demographer county-level population projections. Such projections are based on recent and projected demographic trends, including the birth rates, survival rates, and net migration rates of population groups defined by age, gender and race/ethnicity.

The TSDC develops county-level population projections from 2011 to 2050 under three migration scenarios:

1) no net migration (natural growth only),
2) net migration rates of 2000-2010 (“full-migration scenario”), and
3) 2000-2010 migration rates halved (“half-migration scenario”).

The State Data Center strongly recommends use of the half-migration scenario for long-term-planning. For each county, the draft projection is based on the half-migration scenario as the default, but alternatives (full-migration scenario or a composite of the scenarios) were chosen in select instances where a different scenario was more reflective of anticipated growth patterns.

While the TSDC’s projections extend to 2050, the 2017 State Water Plan will require projections to 2070. TWDB staff has extended the projections to 2060 and 2070 by using the trend of average annual growth rates of the 2011-2050 TSDC projections. In 60 counties, the TSDC-projected population show a decline sometime between 2011 and 2050. For these counties, staff held the county population at its highest point prior to the decline for the following reasons:

1) Small Impact - the difference between holding the populations of these 60 counties constant or projecting continued decline in 2050 is 21,987, or 0.05 percent of the state-wide population of over 41 million. The largest county-specific difference between constant population and declining population is 2,030, the smallest is 17, and the average county difference is 366;
2) Constant System Requirements - projected population decline is often a decline in the number of people per household rather than a reduction in the number of connections that a water system must serve. The water systems must continue to have the capability to serve the customer connections regardless of population.

2.1.2 Water User Group Population Projections

The regional and state water plans require population projections for individual Municipal Water User Groups.

Water User Group Criteria

Municipal water user groups in the regional planning process include:

- Cities with a 2010 population greater than 500;
- Select Census Designated Places, such as military bases and in counties with no incorporated cities;

- Utilities (areas outside the places listed above) providing more than 280 acre-feet of municipal water per year;
- Collections of utilities with a common water supplier or water supplies (Collective Reporting Units); and
- Remaining rural, unincorporated population summarized as "County-Other"

The criterion for including only cities with populations greater than 500 has been used throughout the regional planning process, beginning with the 2001 regional water plans and the 2002 state water plan. Smaller cities are included in the aggregated "County-Other" water use, but are not separately delineated because many such small cities may not have a public water system or may not be the owner of the system. Regional planning groups do have the option of combining smaller water systems/cities into a collective water user group when the systems share a similar source or provider and are anticipated to coordinate in meeting their future water needs. In addition, regions may request the inclusion of cities or systems below the threshold criteria as distinct water user groups. This can be accomodataed in the online planning database.

2.1.2.1 Overlapping Boundaries

The previous section noted various criteria for water user groups. In some cases, the boundaries of qualifying water user groups may overlap. Examples and the method of population and water use allocation include:

•**<u>City utility serving beyond city limits</u>** - The service area boundary of a city-owned water utility may extend beyond the city boundaries; in such cases, the population and associated water use outside of the city limits are allocated not to the city but to the County-Other water user group.

•**<u>Non-city utility serving city residents</u>** – A non-city water utility may provide water directly to residents of a city that qualifies as a water user group; in such cases, the population and associated water use in the shared area are attributed to the city rather than the non-city utility in the regional water plan. Additional information regarding these shared populations and demands can be provided to the RWPGs and their technical consultants.

2.1.3 Projection Methodology

Projections for these individual water user groups are developed by allocating growth from the county projections down to the cities, utilities, and rural areas. The methods of allocating future populations from the county to the sub-county areas include:

1) Share of Growth - applying the water use group's historical (2000-2010) share of the county's growth to future growth;
2) Share of Population - applying the water user group's historical (2000-2010) share of the county population to projected county population; and
3) Constant Population - applied to military bases, and other water user groups that had population decline between 2000 and 2010 in a county with overall population growth.

The sum of all water user group populations within a county is reconciled to the total county projection prior to the finalization of draft projections.

3 Municipal Water Demands:

Draft municipal water demand projections utilize the population projections and a per-person water use volume for each city, water utility and rural area (County-Other). The draft projections will include 2011 per-person water use values (Gallons Per Capita Daily or GPCD) as the initial 'dry-year' water use estimate. Staff then applies future anticipated reductions in water use due to natural replacement rates for adoption of water-efficient fixtures and appliances required by law.

For each municipal water user group, the 2011 GPCD, minus the incremental anticipated savings for each future decade due to water-efficient fixtures/appliances, is multiplied by the projected population to develop the municipal water demand projections.

3.1.1 2011 Gallons Per Capita Daily (GPCD)

The 2011 GPCD for each water user group is calculated by:

- Calculating the net water use of each water system surveyed annually by the TWDB (total intake volume minus sales to large industrial facilities and to other public water suppliers),
- Allocating all or portions of the system net use and applicable estimates of non-system municipal water use (private groundwater) to the planning water user groups (city boundaries or water utility service areas), and
- Dividing the total water use allocated to a water user group by 365 and by the 2011 population estimate.

For city water user groups, the 2011 population estimates from the U.S. Census Bureau were used. Historically, the July 1st population estimates from the Texas State Data Center (TSDC) have been used in GPCD calculation, however because the TSDC had not released their 2011 population estimates by January 2013, staff used the available Census Bureau estimates. For non-city utility water user groups (Districts, Water Supply Corporations, and Investor Owned Utilities), the population reported in the annual water use survey was utilized, with an alternative calculation based on the reported number of connections if necessary.

3.1.2 Minimum GPCD Values

When calculating the base (2011) or projected GPCD values, TWDB staff applied a minimum of 60 GPCD. The minimum value of 60 GPCD is based upon several recent studies: *Analysis of Water Use in New Single-Family Homes*[1] 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.[2] The single-family home study studied the average per-person water use for:

1) Pre-1995 Homes (62.18 GPCD),
2) Standard New Homes built after 2001 (44.15 GPCD),
3) Standard new homes retrofitted with high-water-efficient fixtures and appliances (39.0 GPCD), and
4) New WaterSense Homes built with the best available technology for water conservation (35.6 GPCD).

[1] *Analysis of Water Use in New Single Family Homes*, Prepared by William B. DeOreo of Aquacraft Water Engineering & Management for The Salt Lake City Corporation and the U.S. Environmental Protection Agency, 2011

[2] *The Grass Is Always Greener...Outdoor Residential Water Use In Texas*, Sam Marie Hermitte and Robert Mace, Technical Note 12-01, 2012

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 produces a total residential GPCD of 56.5 GPCD. While some municipal water user groups may remain primarily residential, any water use by the local government or commercial water users will contribute some to the water user groups average GPCD. For this reason, staff rounded the minimum GPCD to 60.

3.1.3 Water Efficiency Savings

Federal standards on plumbing fixtures, dish washers, and clothes washers sold in the U.S. have recently been upgraded with potential savings due to installation of more water efficient units comprising a small, although significant, portion of total water use. Table 1 summarizes the expected savings from adoption of the standards, which apply by Federal Law to the fixtures and appliances sold in the U.S. for each of the effective date years shown. Years shown in Table 1 for each type of fixture/washer are the legislated beginning of sales of those items, with the associated water savings levels mandated by law.

Details concerning each of the pertinent pieces of legislation may be found at the websites noted in Table 2.

Anticipated savings due to water-efficient fixtures/appliances include:

1) Toilets and Showerheads – savings of 16 GPCD;
2) High-Efficiency Toilets – savings of 1.63 GPCD;
3) Dishwashers – savings of 1.61 to 1.90 GPCD; and
4) Clothes Washers – 6.45 GPCD

Table 1. Summary of Water Efficiency Savings and Implementation Years

	1995	2007	2010	2013	2015	2018
Item						
Plumbing Fixtures, 1991 (toilets, showerheads)	***Combined savings:*** **16 GPCD**					
High-Efficiency Toilet, 2009			***Savings:*** **0.32 gal/flush or 1.63 GPCD**			
Dishwashers			***Standard:*** **6.5 gal/cycle** ***Savings*:*** **7.5 gal/cycle or 1.83 GPCD**	***Standard:*** **5 gal/cycle** ***Savings:*** **9 gal/cycle or 1.93 GPCD**		
Front Load Clothes Washers		***Standard:*** **9.5 gal/cycle** ***Savings:*** **17.5 gal/cycle or 5.23 GPCD**			***Standard:*** **4.7 gal/cycle** ***Savings:*** **22.3 gal/cycle or 6.67. GPCD**	
Top Load Clothes Washers		***Standard:*** **9.5 gal/cycle** ***Savings:*** **17.5 gal/cycle or 5.23 GPCD**			***Standard:*** **8.4 gal/cycle** ***Savings:*** **18.6 gal/cycle or 5.56 GPCD**	***Standard:*** **6.5 gal/cycle** ***Savings:*** **20.5 gal/cycle or 6.13 GPCD**

*Savings for dishwashers and clothes washers are calculated versus historical average usage noted below: Dishwashers: 14 gal/cycle, Clothes Washers: 27 gal/cycle (minor use of front load clothes washer previous to 2007). GPCD savings based on assumed 2.75 people per household, 215 dishwasher loads/yr, and 300 clothes washer loads/yr.

Table 2. Background Information on Federal Standards on Water/Energy Efficiency

Item	Effective Year	Website
Plumbing Fixtures	1995	http://www.gao.gov/new.items/rc00232.pdf
High-Efficiency Toilets	2010-2014	www.capitol.state.tx.us (search House Bill 2667, 81st Legislature (Regular) 2009)
Dishwashers	2010	http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/74fr16040.pdf
Dishwashers	2013	http://www1.eere.energy.gov/buildings/appliance_standards/residential/dishwashers.html (see section on Energy Conservation Standards)
Clothes Washers	2007	http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/rcw_dfr_tsd_ch3.pdf (see section 3.7.2)
Clothes Washers	2015, 2018	http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers.html (see section on Energy Conservation Standards)

3.1.4 Plumbing Fixtures Efficiency Savings, 1991 ("Plumbing Code Savings")

The suggested water savings 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 as described in the State Water-Efficient Plumbing Act passed in 1991. Those housing units built before the law came into effect will, over time, replace their old fixtures with the new water-efficient fixtures. TWDB is providing a suggested schedule at which the fixture replacements will take place, and the effect that the replacement will have on the city or utility's average Gallons Per Capita Daily (GPCD).

3.1.4.1 Water Savings

From the a recent study of water conservation, it is estimated that the average savings of replacing higher water-use fixtures with more efficient fixtures mandated by state and federal laws would be 16 gallons per person, per day (10.5 gallons for toilets and 5.5 gallons for showerheads).

3.1.4.2 Replacement Schedule

The TWDB compiles population data rather than housing data, so in calculating the number of houses and the less-efficient fixtures, the Board staff used population as a proxy for the number of houses at the time the law took effect and the projection of future houses. The July 1995 population estimate is used as a benchmark to determine the potential average per-capita water savings of a city or utility. The 1995 population (as a proxy for housing and fixtures) is assumed to have less-efficient fixtures, which can be replaced, lowering their GPCD and the city's or utility's average GPCD. Any population growth after 1995 is expected to inhabit new housing that was built with the more efficient water fixtures. No additional water savings can be expected on the basis of fixture replacement for the post-1995 population. Fixture standards have not changes since the initial law was implemented.

The July 1995 population estimate was chosen as a starting point for adoption of the more efficient fixtures for several reasons. First, in both the state and federal laws affecting plumbing codes, retailers were allowed to continue selling the less-efficient fixtures that they had in stock. Second, in any areas, whether a city or a subdivision served by a utility, there are vacant housing units which will eventually be occupied. Although there was no population in the house, there were less-efficient fixtures that will be used, and replaced, by residents eventually. Third, because we are using a proxy for the number of fixtures and the proxy (population estimate) can have varying degrees of accuracy, the July 1995 estimate was felt to be a good, conservative number.

The annual rate of fixture replacement was estimated to be 2 percent of the 1995 population, implying a 50 year adoption period for the 1995 population of housing. By the year 2045, 100 percent of the 1995 population would have the new water-efficient plumbing fixtures.

STEPS IN CALCULATING THE WATER SAVINGS DUE TO FIXTURE REPLACEMENT

A) Establish the Base 'Dry-Year' and Associated GPCD. Due to the extreme drought experience in 2011, it was decided that the year 2011 GPCD would act as the default 'dry-year' water use figure for all municipal water user groups. However, the base year for the population projections was 2010, so the dry-year GPCD (2011) will be applied to the 2010 base year. All potential water saving calculations are therefore subtracted from this reference GPCD (year 2011, assigned as the year 2010 value) to calculate the expected GPCD for each water user group over time as adoption of the various water saving technologies (fixtures, clothes and dish washers) proceed.

B) Calculate the estimated savings due to replacement between 1995 and 2010. Some fixture replacement took place between the passage of the law and the year 2010. The savings that result decrease the potential water savings available after the year 2010. Using the estimate that 2% of the 1995 population will replace the fixtures each year, 30% of the 1995 replaced their fixtures by the year 2010.

$$\textbf{\textit{EQ. 1: PCS2010}} = \underbrace{((\textbf{\textit{POP1995}} * 30\%) + \textbf{\textit{G1995-10}}) / \textbf{\textit{POP2010}})}_{\text{Calculates the percentage of the 2010 population that has water-efficient fixtures.}} * \underbrace{16\text{ GPCD}}_{\text{The per-person amount saved per replaced toilet and showerhead.}}$$

GPCD2010	Per-person, per-day water use in 2010 (GPCD)
G1995-10	Population growth between 1995 and 2010
PCS2010	The city/utility's average GPCD savings due to plumbing code changes (fixture replacement) between 1995 and 2010.
PCS2020	The city/utility's average GPCD savings due to plumbing code changes (fixture replacement) between 2010 and 2020
POP1995	July 1995 population estimate
POP2010	Census 2010 population (cities) or Year 2010 population estimate (utilities

Note: The per-person savings for each toilet and showerhead replaced is 16 gallons, however this change in GPCD applies for the portion of the 1995 population that replaced fixtures up to the point in time under consideration plus the new housing units in the water use group service area. The average GPCD savings for the entire city or utility will be considerably less than the maximum possible 16 GPCD due to non-replacement of plumbing fixtures by the majority of 1995 housing units. As noted in the calculation above (EQ 1.), the estimated water savings are a combination of the accrued savings due to 30 percent of the 1995 level housing units, plus all of the growth from 1995 to the year 2010.

C) <u>Calculate the remaining savings that will become available in each decade</u>.

EQ. 2: PCS2020 =

$$\left[((\mathbf{\mathit{POP1995}} * 50\%) + (\mathbf{\mathit{POP2020}} - \mathbf{\mathit{P1995}})) / \mathbf{\mathit{POP2020}}) * 16\ \text{GPCD}\right] \text{ minus } \mathbf{\mathit{PCS2010}}$$

Calculates the percentage of the 2010 population that has water-efficient fixtures (30% of the 1995 pop plus the growth between 2010 and 1995, divided by the 2010 total population).

These water-use savings took place before the water-use base year (2000) and cannot be subtracted from the base

Similar water savings calculations (a point estimate for the year 2020 (EQ 2)) combine water savings from 50 percent of the 1995 housing population plus all of the population growth since 1995. Water savings estimated to be in place by 2010 (PCS2010), already implicit in the year 2010 estimated GPCD, are then subtracted from the potential savings to avoid double counting the potential savings.

Estimated GPCD for the year 2020 is then the baseline Dry Year GPCD (***GPCD2010***) less the water savings accumulated up to that point in time.

EQ 3: 2020 Per-Person Water Use (GPCD) =

2010 Per-Person Water Use (*GPCD2000)* MINUS Fixture Efficiency Savings (*PCS2020)*

Note: A formula similar to EQ. 3 would apply for each decade through 2070. By 2060 and 2070 all of the fixture replacements would have taken place and no additional water savings (and GPCD reductions) will occur.

3.1.5 High-Efficiency Toilet Savings, 2009

House Bill 2667 of the 81st Texas Legislature (2009) mandated that all toilets installed in residential and commercial buildings, with limited exemptions be High-Efficiency Toilet, using no more than 1.28 gallons per flush. The act also addressed water efficiency standards for showerheads, urinals, and faucet flow.

3.1.5.1 Water Savings

The 2009 law required that by January 2014, all toilets use no more than 1.28 gallons per flush. This is a 20% savings from the 1.6 gallons per flush standard set in the 1991 Texas law. Based upon an average frequency of per-person toilet use in households of 5.1 and a per-use savings of 0.32 gallons per use the estimated saving of adopting high-efficiency toilets is 1.63 GPCD. The act also required changes to standards for showerheads, from 2.75 gallons per minute to 2.5 gallons per minute, and standards for urinals and faucets, however at the regional water planning level such savings become too detailed and cumbersome to incorporate.

3.1.5.2 Replacement Schedule

To provide toilet manufacturers time to shift production to high-efficiency toilets, the 2009 law allowed a phasing in period by the percent of models offered for sale meeting the 1.28 gallons per flush standard:

- January 1, 2010 – 50% of the models offered for sale
- January 1, 2011 – 67% of the models offered for sale
- January 1, 2012 – 75% of the models offered for sale
- January 1, 2013 – 85% of the models offered for sale
- January 1, 2014 – 100% of the models offered for sale

Similar to the replacement of water-efficient fixtures required by the 1991 law, the replacement of pre-high-efficiency toilet was assumed to be 2 percent per year, with adjustments for the 2010-2014 time period as the high-efficiency toilets are being phased in.

3.1.6 Dishwasher Savings Efficiency Savings

3.1.6.1 Water Savings

The baseline water use per load of dishwashers prior to mandatory efficiency standards was 14 gallons per load. Beginning in 2010, dishwashers were required to use no more than 6.5 gallons per cycle. By 2013 the maximum water use is set at 5 gallons per cycle for all dishwashers produced or sold in the country. Thus, the savings per load for the 2010 machine standards is 7.5 gallons per load (14 gallons – 6.5 gallons) and 9 gallons for the 2013 standards (14 gallons – 5 gallons).

The water efficiency saving for the 2010 – 2020 period is a weighted average of the 2010 and 2013 standards (3 years at 7.5 gal/load plus 7 years at 9 gal/load): 8.55 gallons per load. Water savings after 2020 is the full implementation of the 2013 standards of 5 gallons per load, or a savings of 9 gallons per load.

Table 3. Use and installation assumptions

Metric	Value	Source
People/ household	2.75	Texas State Data Center
Loads/household/yr	215	DOE/EPA estimate
Percentage of new construction installing a new Dishwasher	96.7%	DOE documentation on year 2012 dishwasher standards

Per-person, per day water use saving of the installation of new dishwashers:

<u>Water Savings (2010 to 2020)</u>

= (8.55 gal/load* 215 loads/yr)/(365 days/year * 2.75 people per household)

= 1.83 GPCD max savings for each new dishwasher installed.

<u>Water Savings (2020 to 2070)</u>

= (9 gal/load*215 loads/yr)/(365 days/yr*2.75 people/household)

= 1.93 GPCD max savings for each new dishwasher installed

3.1.6.2 Replacement Schedule and Baseline Adoption Values

A ten year useful life was assumed for dishwashers, with the baseline for dishwashers statewide estimated at 78 percent of existing households for 2010. The latter value is based on metropolitan statistics from the American Housing Survey (http://www.census.gov/housing/ahs/data/metro.html). Therefore, 78 percent of the 2010 population for each water use group was assumed to be the starting point for new, more water efficient dishwasher installation. The ten year useful life implied that ten percent of the 2010 population would install the more water efficient dishwashers each year. It is assumed that all pre-2010 dishwashers have the 14 gal/load water use level, so all benefits of the new standard(s) accrue beginning in 2010, and the updated WUG-specific GPCD values do not have to be adjusted for previous new technology adoption.

3.1.7 Clothes Washer Efficiency Savings

3.1.7.1 Water Savings

The first nationwide standards for residential clothes washers took effect in 2007, requiring both top and front-loading machines to use a maximum of 9.5 gallons per load, compared to a possible use of 27 gallons in pre-efficiency-standard machines. Future efficiency standards will require a maximum usage of 8.4 gallons per load in top-loading machines and 4.7 gallons in front-loading machines in the year 2015. In 2018, the maximum usage for top-loading machines will be reduced further to 6.5 gallons.

Table 4. Parameters for Clothes Washer Savings Calculations

Metric	Value	Source
People Per Household	2.75	Texas State Data Center, 2010 Census
Loads/household/yr	300	DOE/EPA estimate
Proportion of TX households with clothes washers in 2010	75%	American Housing Survey, Metro Stats for 4 major cities in Tx
Percentage of new construction installing a new Clothes Washer	91%	DOE documentation on year 2012 Clothes washer standards
Proportion Top-Loads vs Front-Loads	40% vs 60%	DOE documentation on year 2012 Clothes washer standards
Lifespan of Clothes Washing Machines	Top Load – 14 years, Front Load – 11 years, "Composite" – 12 years	www.bankrate.com/brm/news/pf/20050810c1.asp

Potential Max savings for

- •Both Top Loading and Front Loading Machines (27 gallon -9.5 gallon) = 17.5 gallon for year 2007 standard
- •Top Loading Machines (27 gallon -8.4 gallon) = 18.6 gallon /cycle for year 2015 standard
- •Top Loading Machines (27 gallon -6.5 gallon) = 20.5 gallon /cycle for year 2018 standard
- •Front Loading Machines (27 gallon -4.7 gallon) = 22.3 gallon /cycle for year 2015 standard

3.1.7.2 Replacement Schedule

A twelve year replacement schedule is assumed for the clothes washers. New clothes washer purchases/replacements assume that forty percent of the replacements are top-loading machines and 60 percent are frontloading. A composite machine (i.e., part top-loader and part front-loader) is assumed to ease the water savings calculation process, and a weighted average savings calculation, based upon the respective potential savings of the two types of machines, is performed. The American Housing Survey of 2010 for four major cities in Texas estimated that 75 percent of households have clothes washers. This percentage was applied as a statewide average. In addition, 2012 U.S. Department of Energy studies estimate that 96.7 percent of new residential construction will have clothes washers. These two parameters are used to determine the number of clothes washers eligible for replacement, or will be installed in new constructions as the estimates of potential GPCD savings are calculated for each decade.

Appendix B

Population by Pressure Plane Methodology

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Overview of the methodology used in disaggregating the City of Dallas population / water demand into the major pressure zones.

There are limited existing data sources that provide future water demand projections for the City of Dallas' pressure plane system. The Texas Water Development Board (TWDB) provides population and per capita information at the county and municipality level from which estimates of future demand can be developed for the overall Dallas system and individual wholesale customer cities. Dallas has a water distribution model, developed in 2007 by Black and Veatch and updated in 2011 by CH2MHill, which contains estimates of future demands by pressure zone. For the 2014 Dallas LRWSP, HDR utilized a new method and data not previously available to the other studies, rather than the methods used in the 2007 Black Veatch and 2011 CH2MHill efforts, to estimate micro (pressure plane) demands for the City of Dallas. This methodology combines the population data for each Traffic Serial Zone (TSZ) as obtained from the North Central Texas Council of Governments (NCTCOG), with the TWDB estimates of per capita use and population, and City of Dallas billing data to project water demands by pressure zone for the City of Dallas out to 2070. The new method, which is based on 2016 Region C data, produced a lower 2020 starting projection than the 2011 CH2MHill analysis. TSZs are normally used in traffic planning studies, but can also be used to create smaller discrete study areas within a larger geographic area. Data from the NCTCOG included population estimates/projections for the approximately 1,790 TSZs within the Dallas city limits from 2010 to 2030 in five-year increments (Figure 1).

Using the data supplied by the NCTCOG, the percent of the population living within each TSZ was determined. These population projections by TSZ were extended to 2070 using trend analysis based on comparisons of the overlapping 2010 through 2030 values from each data set. There were no limits to growth placed upon the TSZs. A data check was also performed to ensure that the sum of these percentages equaled 100 percent of the decadal projections. The Region C population projections for the City were then distributed into TSZs using the percentages developed in the previous calculation. Once this was complete, a percent change in population was calculated for each TSZ for each five-year period through 2070. These percent changes were then used to project municipal and commercial water demands as described in the following text.

The City of Dallas provided an initial list of 422,829 customer accounts, with address and water consumption data, in 23 separate files in February 2013. An additional file containing 19,081 customer accounts was provided in October 2013. In all, a total of 441,910 customer accounts were processed. These files were combined into one file to be geo-located. Geo-location is the process of attributing data to a specific geographic location in GIS applications. This file contained account attributes that allowed the accounts to be separated into use type (residential, commercial, industrial, or wholesale) as well as meter location information so that the account could be accurately located within the City of Dallas distribution system. HDR worked closely with City of Dallas staff to refine addresses where location data were incomplete or missing.

Once this process was complete, the account locations were geocoded using the provided account location information and parcel information from the Dallas County and Denton County Appraisal Districts.

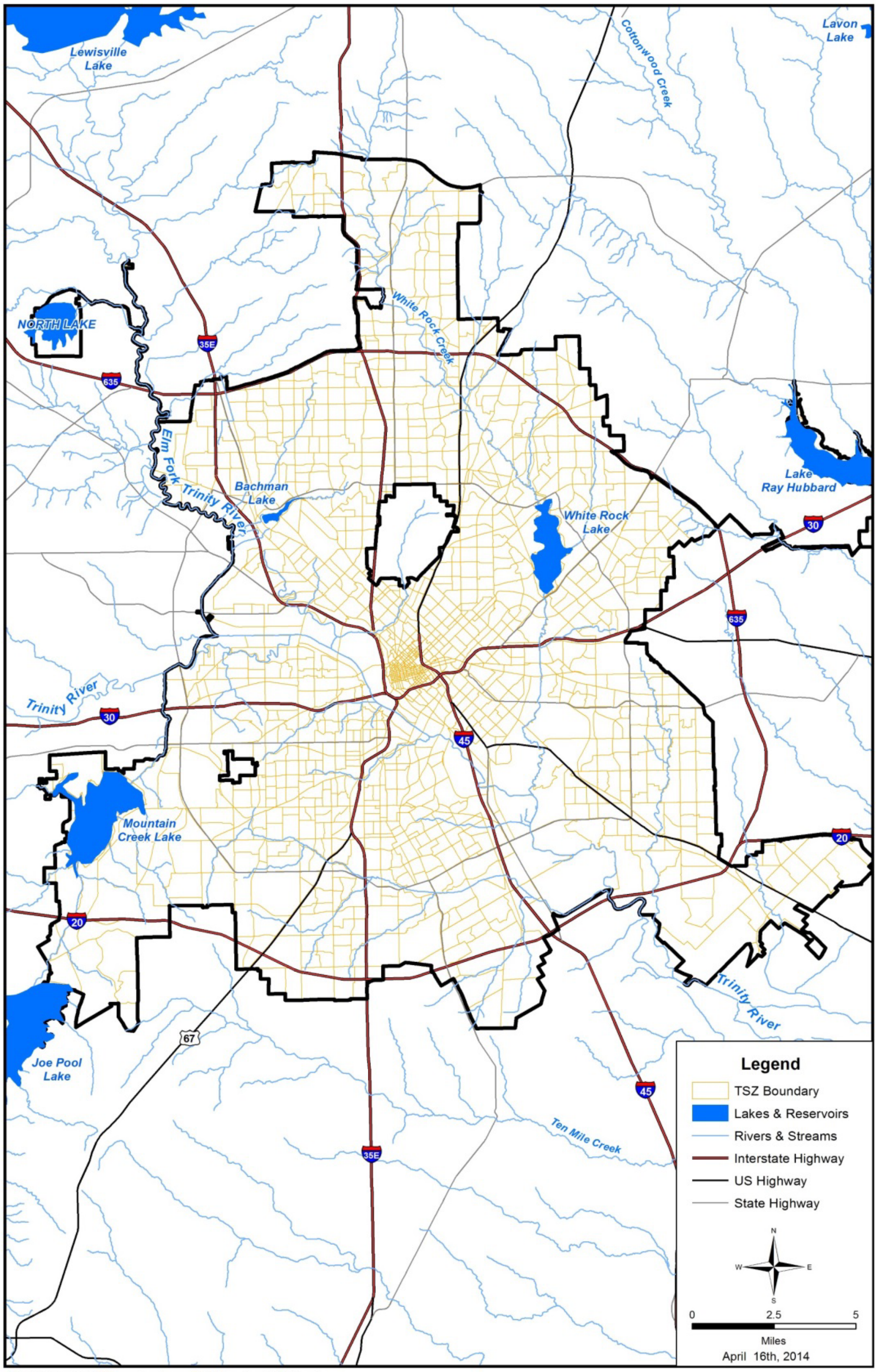

Figure 1. Traffic Serial Zones Within Dallas City Limits

Some of the issues encountered during the geocoding process were:

- Customer accounts with invalid addresses – There were a total of 1,789 accounts (0.4%) with invalid addresses that could not be used to geo-locate the customer location. In some instances, there was no street name given.
- Incorrect geocoded location – 576 customer accounts (0.1%) were found to be located incorrectly. All geocoded customer accounts were checked to verify that the listed zip code in the customer record matched the geographical zip code boundaries obtained from the U.S. Census Bureau. Allowances were made for those accounts that fell within a 1,000 foot buffer of the zip code boundary. Geocoded locations that had zip code information that did not match, but fell within the buffer zone were considered to be valid locations.
- Not geocoded – 295 customer accounts (0.07%) could not be geo-located based on the listed address.

In all, a total of 2,660 customer accounts, roughly 0.6% of the total number of utility customers, were not geocoded. Due to the methodology selected, these accounts were not included in the consumption data used to derive the micro-demand forecasts. This was determined to be an acceptable approach, since the final demand projections for the City were adjusted to fit the Region C water demands. Not including these accounts made no difference in the total demand projections and very little, if any, differences to the pressure zone projections.

Once each account had been properly geocoded, these accounts were then assigned to one of the TSZs within the City of Dallas. Using the use data supplied for year 2011, the base year of the Texas Water Development Board (TWDB) forecast, a value for municipal, commercial, and manufacturing use was determined.

Municipal and commercial water demand was forecasted by applying the percentage increase in population from the NCTCOG data to the water use data for each five-year period. For example, if after the geocoding process, the water use data supplied by Dallas showed that a TSZ had municipal and commercial use of 10,000 acft in 2011 (an assumption was made that the use in 2010 would have been a fair representation of the 2011 data) and the NCTCOG data showed a 3% increase in population from 2010 to 2015 for this TSZ, then the municipal and commercial water demand for this TSZ was also increased 3% from 2010 to 2015. In this case, the forecasted municipal and commercial water demand for this TSZ would be 10,300 acft/yr for 2015 (10,000 acft plus 3% growth equals 10,300 acft). Next, the total municipal and commercial water demand for all TSZs was totaled and compared to the water demand projections contained in the 2016 Region C Regional Water Plan (RWP) for the City of Dallas. The individual demands for the TSZs were then scaled so that the total demand assigned to the TSZs would equal the total demand contained within the Region C RWP, in order for this analysis to be consistent with the demand projections developed for the LRWSP.

Manufacturing demand was determined by applying the percent of all manufacturing demand assigned to each TSZ to the manufacturing demands for Dallas County contained within the Region C RWP. For example, if it was determined from the

2011 water use data that a TSZ contained 5% of the total manufacturing water use and in 2020 the total manufacturing demand for Dallas County was 27,210 acft, then that TSZs water demand forecast for 2020 would be 1,360.5 acft (27,210 acft x 5%).

The projected municipal, commercial and manufacturing demands developed using the methodologies above were then summed to obtain a total water demand projection for each TSZ within the City of Dallas. Current pressure zone boundaries were supplied by the City of Dallas. The pressure zones were then overlaid onto the TSZ boundaries and each TSZ was assigned to a pressure zone. If a TSZ straddled a pressure zone boundary, that TSZ was assigned to the pressure zone in which the majority of the TSZ is located in. Finally, the demands for each pressure zone were determined by summing the demands of each TSZ associated with that pressure zone.

The City's wholesale customers' treated water demands were assigned to a pressure zone based upon data contained in the Black & Veatch report, which indicated from which pressure zone a wholesale customer received their water. These demands were then added to the City of Dallas demands to determine a total demand for each pressure zone.

Appendix C

Population Projection by Entity

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City of Addision							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	17,919	19,800	20,000	20,000	20,000	20,000	
2011 Region C Plan	16,000	20,534	22,358	23,629	24,515	25,133	
2014 LRWSP	13,056	14,539	17,431	20,323	23,215	26,107	29,000
City of Carrollton							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	121,000	125,000	133,000	137,000	140,000	140,000	
2011 Region C Plan	121,000	124,000	128,500	131,320	133,450	134,800	
2014 LRWSP	119,097	126,763	129,176	129,179	129,182	129,185	129,188
City of Cedar Hill							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	47,000	70,000	81,000	82,000	82,000	82,000	
2011 Region C Plan	46,255	66,728	78,085	81,622	81,622	81,622	
2014 LRWSP	45,028	53,200	65,119	77,038	88,956	88,956	88,956
City of Cockrell Hill							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	4,782	4,947	5,028	5,067	5,086	5,095	
2011 Region C Plan	4,782	4,947	5,028	5,067	5,086	5,095	
2014 LRWSP	4,193	4,670	5,122	5,122	5,122	7,000	15,000
City of Combine							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2014 LRWSP		2,690	3,278	3,939	4,692	5,545	6,501
Combine WSC							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	6,515	8,706	10,676	12,814	15,487	18,848	
2011 Region C Plan	6,515	8,706	10,676	12,814	15,487	18,848	
2014 LRWSP		15,829	17,093	24,432	38,000	65,000	90,000
City of Coppell							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	40,000	40,000	40,000	40,000	40,000	40,000	
2011 Region C Plan	40,415	40,577	40,715	40,832	40,932	41,016	
2014 LRWSP	38,659	41,460	42,953	42,953	42,953	42,953	42,953
City of Dallas							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	1,312,324	1,451,878	1,525,450	1,598,222	1,650,000	1,700,000	
2011 Region C Plan	1,312,324	1,415,000	1,495,000	1,598,223	1,764,681	2,058,767	
2014 LRWSP	1,197,816	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498

Dallas County WCID #6/City of Balch Springs							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	21,083	22,564	23,849	24,963	25,930	26,768	
2011 Region C Plan	21,083	22,564	23,849	24,963	25,930	26,768	
2014 LRWSP	23,728	26,423	28,980	31,606	34,456	37,233	40,018
Dallas County-Other							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2014 LRWSP		5,339	3,000	2,000	2,000	2,000	2,000
City of Denton							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	131,000	191,000	250,000	305,000	363,586	420,000	
2011 Region C Plan	120,726	173,980	229,964	295,000	363,586	498,488	
2014 LRWSP	113,383	158,398	205,977	262,057	341,471	468,168	570,694
City of DeSoto							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	47,649	57,000	73,000	75,000	75,000	75,000	
2011 Region C Plan	47,649	57,243	65,849	73,881	82,923	85,400	
2014 LRWSP	49,047	54,617	59,903	65,330	71,222	76,963	82,718
DFW Airport							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2014 LRWSP							
City of Duncanville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	37,100	38,500	41,800	42,000	42,000	42,000	
2011 Region C Plan	37,100	37,100	37,100	37,100	37,100	37,100	
2014 LRWSP	38,524	42,927	47,106	47,106	47,106	47,106	47,106
City of Farmers Branch							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	30,470	34,500	39,500	40,215	40,215	40,215	
2011 Region C Plan	30,470	33,161	35,608	37,833	39,855	41,693	
2014 LRWSP	28,616	30,613	32,509	34,455	36,567	38,625	40,689
City of Flower Mound							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	78,500	89,000	93,000	93,000	93,000	93,000	
2011 Region C Plan	66,667	75,555	93,000	93,000	93,000	93,000	
2014 LRWSP	64,669	75,555	93,000	93,000	93,000	93,000	93,000

City of Glenn Heights							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	14,500	25,000	29,000	30,000	30,000	30,000	
2011 Region C Plan	12,925	15,607	18,558	21,410	24,327	27,292	
2014 LRWSP	11,278	17,323	23,308	29,590	36,506	43,522	59,000
City of Oak Leaf							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2014 LRWSP		1,350	1,500	1,750	2,500	3,700	4,500
City of Grand Prairie							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	175,987	212,932	250,000	265,000	265,000	265,000	
2011 Region C Plan	170,000	196,000	231,011	260,015	290,520	290,520	
2014 LRWSP	175,396	218,162	258,759	283,493	283,515	283,541	283,571
City of Grapevine							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	51,352	55,000	60,000	60,000	60,000	60,000	
2011 Region C Plan	51,352	55,000	60,000	60,000	60,000	60,000	
2014 LRWSP	46,334	52,414	58,930	60,000	60,000	60,000	60,000
City of Hutchins							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	5,000	10,000	14,000	15,000	15,000	15,000	
2011 Region C Plan	7,000	8,400	10,200	14,000	22,500	36,000	
2014 LRWSP	5,338	9,903	13,922	17,941	21,960	25,979	30,000
City of Wilmer							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2014 LRWSP		4,203	4,698	7,500	14,000	22,000	40,000
City of Irving							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	214,000	219,000	227,500	235,000	235,000	235,000	
2011 Region C Plan	219,238	240,099	255,853	267,751	276,736	283,521	
2014 LRWSP	216,290	260,752	284,500	284,500	284,500	284,500	284,500
City of Lancaster							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	50,000	68,000	82,000	92,500	106,000	120,000	
2011 Region C Plan	38,000	59,664	65,301	65,304	65,301	65,301	
2014 LRWSP	36,361	45,184	58,895	69,717	77,649	85,582	93,514

City of Lewisville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	111,000	140,000	149,500	149,500	149,500	149,500	
2011 Region C Plan	97,709	110,002	122,002	136,002	155,002	176,515	
2014 LRWSP	95,290	107,327	121,924	139,368	158,857	177,356	177,356

City of Ovilla							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	4,750	6,250	7,750	9,250	9,900	10,000	
2011 Region C Plan	3,850	6,070	8,290	10,508	11,050	11,846	
2014 LRWSP	3,492	4,525	5,791	7,249	8,946	10,917	20,000
City of Red Oak							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	11,500	17,000	23,500	27,252	27,525	27,525	
2011 Region C Plan	12,500	21,000	26,000	28,000	30,000	32,000	
2014 LRWSP	10,769	12,369	14,000	19,000	26,000	32,000	50,000
City of Seagoville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	16,668	23,000	29,000	30,000	30,000	30,000	
2011 Region C Plan	13,017	16,327	19,537	22,848	25,536	27,517	
2014 LRWSP	14,835	18,854	22,873	26,892	30,911	35,000	35,000
City of The Colony							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	42,800	56,000	64,000	71,000	77,000	80,355	
2011 Region C Plan	40,500	56,000	63,000	65,000	67,000	67,600	
2014 LRWSP	36,328	51,000	58,000	62,000	67,600	67,600	67,600
Upper Trinity MWD							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	190,785	270,563	367,814	506,472	650,925	756,465	
2011 Region C Plan	251,082	360,783	487,554	625,869	777,841	879,034	
2014 LRWSP		364,350	501,727	616,702	750,215	840,481	947,594
DWU System							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	2,783,684	3,255,640	3,640,367	3,966,255	4,248,154	4,481,771	
2011 Region C Plan	2,788,159	3,225,047	3,633,038	4,031,991	4,513,980	5,104,876	
2014 LRWSP	2,387,527	3,062,874	3,527,191	3,995,923	4,488,158	4,941,083	5,335,956

Appendix D

Summary of Total Water Demand Projections by Entity

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City	Projected Water Demand (MGD)					
	2020	2030	2040	2050	2060	2070
City of Dallas						
Arcadia Park	0.6	0.8	0.9	1.1	1.3	1.4
Cedar Dale High	1.3	2.6	3.4	4.4	5.4	6.2
Central Low	69.7	71.2	78.3	85.2	92.4	95.4
East High	18.3	17.1	17.2	17.1	16.5	15.3
Meandering Way High	15.8	14.9	15.2	15.4	15.1	14.2
Mountain Creek High	4.4	4.8	7.2	9.3	11.3	12.8
North High	87.8	98.2	112.0	126.0	136.0	142.0
Pleasant Grove Intermediate	13.4	13.4	14.7	15.9	16.7	17.0
Red Bird High	7.9	9.5	11.9	14.3	16.5	18.1
South High	21.6	23.8	26.2	29.2	31.6	32.8
Trinity Heights Intermediate	4.8	4.5	4.6	4.6	4.4	4.1
City of Dallas Total (A)	**245.6**	**260.8**	**291.6**	**322.5**	**347.2**	**359.3**
Current Customer Cities						
Treated Water Customer Demand on Dallas (from Table 4-10 and 4-11)						
Addison	5.4	6.3	7.3	8.4	9.4	10.4
Carrollton	21.0	21.0	20.6	20.4	20.4	20.4
Cedar Hill	9.3	11.3	13.2	15.2	15.2	15.2
Cockrell Hill	0.4	0.4	0.4	0.4	0.5	1.0
Combine/Combine WSC	0.3	0.3	0.4	0.4	0.5	0.6
Coppell	9.8	10.0	9.9	9.9	9.9	9.9
Balch Springs	2.5	2.6	2.7	2.9	3.2	3.4
Dallas County-Other	0.8	0.4	0.3	0.3	0.3	0.3
DeSoto	8.4	9.0	9.7	10.5	11.3	12.2
DFW Airport	2.6	2.8	3.1	3.4	3.8	4.1
Duncanville	5.4	5.7	5.6	5.5	5.5	5.5
Farmers Branch	8.1	8.4	8.8	9.3	9.8	10.4
Flower Mound	7.6	7.8	7.8	7.8	7.8	7.8
Glenn Heights	1.5	2.1	2.6	3.2	3.9	5.3
Oak Leaf	0.1	0.1	0.1	0.2	0.3	0.4
Grand Prairie	19.6	27.8	30.4	30.3	29.9	30.0
Hutchins	0.9	1.2	1.6	1.9	2.3	2.6
Wilmer	0.4	0.4	0.6	1.2	1.8	3.4
Irving	15.3	4.5	4.5	4.5	4.5	4.5
Lancaster	6.8	8.6	10.1	11.2	12.3	13.5
Lewisville	1.1	3.9	6.9	9.9	12.8	12.8
Ovilla	1.0	1.2	1.5	1.8	2.2	4.1
Red Oak	0.1	0.1	0.4	0.7	0.9	1.7
Seagoville	1.8	2.2	2.5	2.8	3.2	3.2
The Colony	5.9	5.9	6.2	6.7	6.5	6.3
Non-Municipal Customers	26.0	28.0	30.0	31.6	31.8	32.0
Treated Water Customers (B)	**162.1**	**172.0**	**187.2**	**200.4**	**210.0**	**221.0**
Untreated Water Customer Demand on Dallas (from Table 4-13)						
Denton	0.0	1.9	8.8	20.3	40.3	56.7
Grapevine	3.1	3.4	3.4	3.3	3.1	3.0
Lewisville	18.0	18.0	18.0	18.0	18.0	18.0
UTRWD	34.2	41.6	42.9	44.2	53.8	54.0
Irrigation	1.3	1.3	1.3	1.3	1.3	1.3
Steam-Electric Power	4.5	4.5	4.5	4.5	4.5	4.5
Total Untreated Water Customers (F)	61.1	70.7	78.9	91.6	121.0	137.5
Total Demand Untreated and Treated Water (D=A+B+C)	**468.8**	**503.5**	**557.7**	**614.5**	**678.2**	**717.8**

*** These customers have multiple sources of water. See Appendix page D-2 for their total demands and adjustments to account for these other supplies.**

City	Projected Water Demand (MGD)					
	2020	2030	2040	2050	2060	2070
Treated Water Customers With Multiple Sources Total Demand						
Cedar Hill	9.5	11.5	13.4	15.4	15.4	15.4
Dallas County-Other	1.5	0.9	0.6	0.6	0.6	0.6
DFW Airport	5.4	5.2	5.1	8.4	11.2	15.3
Flower Mound	17.0	20.6	20.5	20.5	20.4	20.4
Glenn Heights	1.7	2.2	2.8	3.4	4.0	5.5
Oak Leaf	0.1	0.1	0.2	0.2	0.3	0.4
Grand Prairie	39.6	44.7	47.9	47.8	47.8	48.0
Irving	50.1	53.7	53.0	52.7	52.6	52.6
Lancaster	6.9	8.7	10.2	11.3	12.4	13.6
Red Oak	1.6	1.8	2.5	3.3	4.1	6.4
The Colony	6.9	7.7	8.1	8.8	8.8	8.8
Treated Water Adjustments						
Cedar Hill Groundwater	0.2	0.2	0.2	0.2	0.2	0.2
Dallas County-Other Supplied by Other Sources	0.7	0.5	0.3	0.3	0.3	0.3
DFW Airport Supplied by Fort Worth	2.8	2.4	2.0	5.0	7.4	11.2
Flower Mound Supplied by UTRWD	9.4	12.8	12.7	12.7	12.6	12.6
Glenn Heights Groundwater	0.2	0.1	0.2	0.2	0.1	0.2
Oak Leaf Supplied by Rockett SUD	0.05	0.05	0.05	0.05	0.05	0.05
Grand Prairie Supplied by Other Sources	20.0	16.9	17.5	17.5	17.9	18.0
Irving Supplied by Other Sources	34.8	49.2	48.5	48.2	48.1	48.1
Lancaster Supplied by Rockett SUD	0.1	0.1	0.1	0.1	0.1	0.1
Red Oak Supplied by Rockett SUD and Groundwater	1.5	1.7	2.1	2.6	3.2	4.7
The Colony Supplied by NTMWD	1.0	1.8	1.9	2.1	2.3	2.5
Treated Demand on the Dallas System from Customers with Multiple Sources						
Cedar Hill	9.3	11.3	13.2	15.2	15.2	15.2
Dallas County-Other	0.8	0.4	0.3	0.3	0.3	0.3
DFW Airport	2.6	2.8	3.1	3.4	3.8	4.1
Flower Mound	7.6	7.8	7.8	7.8	7.8	7.8
Glenn Heights	1.5	2.1	2.6	3.2	3.9	5.3
Oak Leaf	0.1	0.1	0.1	0.2	0.3	0.4
Grand Prairie	19.6	27.8	30.4	30.3	29.9	30.0
Irving	15.3	4.5	4.5	4.5	4.5	4.5
Lancaster	6.8	8.6	10.1	11.2	12.3	13.5
Red Oak	0.1	0.1	0.4	0.7	0.9	1.7
The Colony	5.9	5.9	6.2	6.7	6.5	6.3
Untreated Water Customers With Multiple Sources Total Demand						
Denton	27.8	35.6	44.4	55.7	75.5	91.5
Grapevine	20.5	22.3	22.5	22.4	22.4	22.4
UTRWD	42.4	60.5	75.7	93.7	103.6	115.0
Steam-Electric Power	4.5	4.5	9.9	9.9	9.9	9.9
Untreated Water Adjustments						
Denton Supplied by Other Sources	27.8	33.7	35.6	35.4	35.2	34.8
Grapevine Supplied by Other Sources	17.4	18.9	19.1	19.1	19.3	19.4
UTRWD Supplied by Other Sources	8.2	18.9	32.8	49.5	49.8	61.0
Steam-Electric Power Supplied by Other Sources	0.0	0.0	5.4	5.4	5.4	5.4
Untreated Water Demand on the Dallas System from Customers with Multiple Sources						
Denton Supplied by Other Sources	0.0	1.9	8.8	20.3	40.3	56.7
Grapevine Supplied by Other Sources	3.1	3.4	3.4	3.3	3.1	3.0
UTRWD Supplied by Other Sources	34.2	41.6	42.9	44.2	53.8	54.0
Steam-Electric Power Supplied by Other Sources	4.5	4.5	4.5	4.5	4.5	4.5

Appendix E

Comparison of Water Demand Projections – 2005 LRWSP, 2011 Region C RWP, and 2014 LRWSP

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City of Addision							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	8,008	8,792	8,837	8,826	8,803	8,803	
2011 Region C Plan	7,904	10,074	10,919	11,514	11,918	12,218	
2016 LRWSP		6,053	7,062	8,183	9,416	10,537	11,658
City of Carrollton							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	27,597	28,134	26,669	30,274	30,800	30,800	
2011 Region C Plan	26,001	26,224	26,882	27,174	27,465	27,741	
2016 LRWSP		23,541	23,541	23,093	22,868	22,868	22,868
City of Cedar Hill							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	8,960	13,126	15,109	15,131	15,131	15,131	
2011 Region C Plan	10,104	14,351	16,706	17,280	17,280	17,280	
2016 LRWSP		10,425	12,667	14,797	17,039	17,039	17,039
City of Cockrell Hill							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	661	672	661	650	650	650	
2011 Region C Plan	653	687	681	670	667	668	
2016 LRWSP		448	448	448	448	561	1,121
City of Combine							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan	282	356	405	463	537	635	
2016 LRWSP		336	336	448	448	561	673
City of Coppell							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	8,837	8,837	8,837	8,837	8,837	8,837	
2011 Region C Plan	11,544	11,500	11,447	11,434	11,417	11,440	
2016 LRWSP		10,986	11,210	11,098	11,098	11,098	11,098
City of Dallas							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	352,565	385,638	400,546	416,405	428,221	441,202	
2011 Region C Plan	374,848	399,421	416,979	442,190	486,268	567,304	
2016 LRWSP		275,318	292,357	326,884	361,523	389,211	402,775

* All values shown are in acft/yr.

Dallas County WCID #6/City of Balch Springs							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	2,442	2,699	2,778	2,834	2,923	3,013	
2011 Region C Plan	2,621	2,730	2,805	2,852	2,934	3,028	
2016 LRWSP		2,803	2,915	3,027	3,251	3,587	3,811
Dallas County-Other							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan	190	146	110	81	60	47	
2016 LRWSP		897	448	336	336	336	336
City of Denton							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	27,888	40,667	52,718	64,008	76,306	88,144	
2011 Region C Plan	24,612	34,884	45,594	58,158	71,679	98,275	
2016 LRWSP		0	2,130	9,865	22,756	45,176	63,561
City of DeSoto							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	9,666	11,614	14,728	14,974	14,672	14,448	
2011 Region C Plan	10,355	12,375	14,162	15,807	17,741	18,271	
2016 LRWSP		9,416	10,089	10,874	11,771	12,667	13,676
DFW Airport							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	6,250	9,061	11,872	11,872	11,872	11,872	
2011 Region C Plan							
2016 LRWSP		2,915	3,139	3,475	3,811	4,260	4,596
City of Duncanville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	6,843	7,101	7,504	7,325	7,112	6,899	
2011 Region C Plan	7,605	7,563	7,522	7,439	7,356	7,356	
2016 LRWSP		6,053	6,390	6,278	6,166	6,166	6,166
City of Farmers Branch							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	12,141	13,922	15,814	16,027	15,982	15,982	
2011 Region C Plan	11,229	12,109	12,883	13,603	14,286	14,945	
2016 LRWSP		9,080	9,416	9,865	10,425	10,986	11,658
City of Flower Mound							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	14,963	16,419	16,498	16,498	16,498	16,498	
2011 Region C Plan	17,325	23,189	32,085	32,085	32,085	32,085	
2016 LRWSP		8,520	8,744	8,744	8,744	8,744	8,744

* All values shown are in acft/yr.

City of Glenn Heights							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	1,837	3,147	3,618	3,707	3,685	3,651	
2011 Region C Plan	1,745	2,067	2,409	2,750	3,095	3,474	
2016 LRWSP		1,682	2,354	2,915	3,587	4,372	5,941
City of Oak Leaf							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2016 LRWSP		112	112	112	224	336	448
City of Grand Prairie							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	28,549	33,891	39,290	41,373	41,104	41,104	
2011 Region C Plan	29,134	33,266	38,426	43,251	48,325	48,325	
2016 LRWSP		21,972	31,164	34,078	33,966	33,518	33,630
City of Grapevine							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	2,016	2,016	2,016	2,016	2,016	2,016	
2011 Region C Plan	17,256	18,298	19,827	19,692	19,625	19,625	
2016 LRWSP		3,475	3,811	3,811	3,699	3,475	3,363
City of Hutchins							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	1,310	2,834	3,931	4,211	4,211	4,211	
2011 Region C Plan	821	1,008	1,255	1,624	2,123	3,497	
2016 LRWSP		1,009	1,345	1,794	2,130	2,578	2,915
City of Wilmer							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP							
2011 Region C Plan							
2016 LRWSP		448	448	673	1,345	2,018	3,811
City of Irving							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	53,155	56,616	60,659	63,851	63,851	63,851	
2011 Region C Plan	58,202	66,967	70,502	73,780	76,256	78,126	
2016 LRWSP		17,151	5,045	5,045	5,045	5,045	5,045
City of Lancaster							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	6,787	9,027	10,718	12,006	13,754	15,568	
2011 Region C Plan	5,704	8,755	9,436	9,363	9,363	9,363	
2016 LRWSP		7,623	9,641	11,322	12,555	13,788	15,134

* All values shown are in acft/yr.

City of Lewisville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	41,989	47,264	48,955	48,810	48,653	48,653	
2011 Region C Plan	19,262	21,316	23,505	26,050	29,516	33,612	
2016 LRWSP		21,411	24,550	27,913	31,276	34,527	34,527

City of Ovilla							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	874	1,142	1,400	1,658	1,781	1,792	
2011 Region C Plan	992	1,550	2,099	2,648	2,784	2,985	
2016 LRWSP		1,121	1,345	1,682	2,018	2,466	4,596

City of Red Oak							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	1,971	2,946	4,021	4,693	4,659	4,659	
2011 Region C Plan	2,366	4,022	4,922	5,269	5,612	5,986	
2016 LRWSP		112	112	448	785	1,009	1,906

City of Seagoville							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	2,666	3,595	4,469	4,592	4,592	4,592	
2011 Region C Plan	2,085	2,542	3,019	3,480	3,890	4,191	
2016 LRWSP		2,018	2,466	2,803	3,139	3,587	3,587

City of The Colony							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	5,813	7,840	8,949	9,934	10,774	11,245	
2011 Region C Plan	5,761	7,778	8,609	8,810	9,006	9,087	
2016 LRWSP		6,614	6,614	6,950	7,511	7,287	7,062

Upper Trinity MWD							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	30,498	48,395	79,565	105,638	133,448	154,011	
2011 Region C Plan	10,000	46,290	56,656	58,438	60,066	72,638	
2016 LRWSP		38,338	46,634	48,091	49,548	60,310	60,534

DWU Total Customer Municipal Demand							
Plan	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**
2005 LRWSP	664,958	766,347	851,304	917,505	971,970	1,019,614	
2011 Region C Plan	659,063	770,156	840,700	896,940	972,622	1,103,764	
2016 LRWSP		489,877	526,534	585,050	646,929	718,113	762,280

* All values shown are in acft/yr.

Appendix F

Additional Water Rights Owned by the City of Dallas

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Summary of Additional Dallas Water Rights Owned by the City of Dallas

Units: as noted in table

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)

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Appendix G

2016 Region C Water Plan Return Flow Estimates Available to Dallas

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DRAFT MEMORANDUM

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TO: File

CC: Tom Gooch, Amy Kaarlela, Keeley Kirksey

FROM: Rachel A. Ickert, P.E.

SUBJECT: Dallas Reuse Supplies

DATE: January 30, 2014

1. Dallas has permits and agreements that allow it to use return flows from wastewater treatment plants operated by Denton, Lewisville, Flower Mound, and North Texas Municipal Water District (NTMWD WWTPs discharging to the Lake Ray Hubbard watershed and discharging to the Lake Lewisville watershed). Dallas' water rights allow Dallas to capture return flows from the City of Lewisville and the Town of Flower Mound wastewater treatment plants along the Elm Fork of the Trinity River. Dallas will also be able to use all NTMWD permitted return flows discharging into the Lake Ray Hubbard watershed once a Main Stem Pump Station is completed.

2. Dallas has a memorandum of understanding with Denton that describes how Denton's wastewater treatment plant discharges into Lake Lewisville are divided between Denton and Dallas. Denton can use 50% of its discharges to Lake Lewisville capped at 50% of Denton's firm supply in Lakes Lewisville and Ray Roberts. Dallas can use the remaining discharges from Denton.

3. Dallas has an agreement with Upper Trinity Regional Water District that allows UTRWD to reuse actual UTRWD discharges to Lake Lewisville up to 60 percent of the water imported by UTRWD from Lake Chapman. In addition, one of UTRWD's water management strategies is Lake Ralph Hall Reuse, which is assumed to be 60% of supplies imported by UTRWD from Lake Ralph Hall; however, UTRWD will need to negotiate an agreement with Dallas for return flows associated Lake Ralph Hall. This supply is assumed to be available starting in 2020. Dallas can make use of UTRWD discharges to Lake Lewisville in excess of the reuse allocated to UTRWD (discharges to Lake Lewisville limited by Lake Chapman imports plus Lake Ralph Hall reuse).

4. Dallas has an agreement with NTMWD to use all discharges to Lake Lewisville from NTMWD-operated WWTPs in Frisco once NTMWD obtains a reuse permit for the return flows. This water will be exchanged for reuse supplies that will be diverted from the main stem of the Trinity downstream of the DWU Southside WWTP to NTMWD's East Fork Wetlands when a Main Stem Pump Station is completed.

5. Once the main stem pump station is completed, Dallas can use all NTMWD discharges into the Lake Ray Hubbard watershed. Dallas is entitled to NTMWD WWTP discharges in the Lake Ray Hubbard watershed once the main stem pump station is completed or if the flows are not needed by NTMWD.

6. The projected available reuse supplies for Dallas are listed in Table 1. The projected reuse supplies from NTMWD discharges in the Lake Ray Hubbard watershed are listed in Table 2. Note that the supplies in Table 2 are not currently available. They are based on a recommended water management strategy.

Table 1
Available Reuse Supplies for Dallas
(Acre-Feet per Year)

Source	2020	2030	2040	2050	2060	2070
Lewisville and Flower Mound Return Flows (Includes return flows from 17% of Denton County Manufacturing) [a]	17,747	20,641	21,899	23,391	24,872	24,884
Dallas' share of Denton Return Flows to Lake Lewisville [b]	6,774	8,729	10,922	14,724	24,828	33,064
Dallas' share of UTRWD Return Flows to Lake Lewisville [c]	0	0	0	4,054	6,560	7,834
NTMWD Discharges to Lake Lewisville [d]	7,735	6,278	7,847	7,847	7,847	7,847
TOTAL	**32,256**	**35,648**	**40,668**	**50,016**	**64,107**	**73,629**

Notes: a. Values were calculated by applying a 45% return flow factor to the total Region C water demand projections for Lewisville, Flower Mound, and 17% of Denton County Manufacturing.

b. Values for Denton's share of return flows are limited to 50% of Denton's projected discharges to Lake Lewisville capped at 50% of Denton's firm supply in Lakes Lewisville and Ray Roberts. Dallas' share is the remaining return flows.

c. Values were calculated based on water reclamation population projections provided by UTRWD and 75 gpcd for return flows. UTRWD's share is limited to 60% of the water imported by UTRWD from Lake Chapman. Lake Ralph Hall Reuse is a recommended water management strategy for UTRWD, so 60% of the water to be imported by UTRWD from Lake Ralph Hall was added to UTRWD's reuse supplies beginning in 2020; however, UTRWD will need to negotiate an agreement with Dallas for return flows associated Lake Ralph Hall. Dallas' share is the remaining return flows.

d. Values were calculated based on reuse and return flow calculations done for the North Texas Municipal Water District in 2013 (NTD13507, FY 2014 WR planning for NTMWD).

Table 2
Reuse Supplies from NTMWD Discharges in the Lake Ray Hubbard Watershed
(Acre-Feet per Year)

Source	2020	2030	2040	2050	2060	2070
NTWMD WWTP Discharges to the Lake Ray Hubbard Watershed [a]	25,895	30,828	34,863	34,863	34,863	34,863

Notes: a. The Main Stem Pump Station is currently in the design phase and is not due to be completed until sometime in the future. Values were calculated based on reuse and return flow calculations done for the North Texas Municipal Water District in 2013 (NTD13507, FY 2014 WR planning for NTMWD).

Table 3 shows the available reuse supplies for Dallas that were included in the *2011 Region C Water Plan* and the updated reuse supplies for the *2016 Region C Water Plan*.

Table 3
Available Reuse Supplies for Dallas in the 2011 Region C Plan and 2016 Region C Plan
(Acre-Feet per Year)

	2020	2030	2040	2050	2060	2070
2011 Plan	42,046	53,147	60,646	69,861	85,000	N/A
2016 Plan	32,256	35,648	40,668	50,016	64,107	73,629
Difference	*9,790*	*17,499*	*19,978*	*19,845*	*20,893*	

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Appendix H

Conservation Pool Capacities and Dead Pool Storages Used for Model Simulations

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Table H-1. Lake Grapevine Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 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	192	712	480.0	52	83
485.0	384	1,424	485.0	104	165
490.0	623	2,888	490.0	228	590
495.0	1,154	7,241	495.0	712	2,843
500.0	1,838	14,764	500.0	1,362	8,066
500.5[2]	1,906	15,630	500.5[2]	1,427	8,697
505.0	2,443	25,253	505.0	1,947	16,128
510.0	3,206	39,266	510.0	2,703	27,638
515.0	3,859	57,251	515.0	3,364	43,130
520.0	4,479	78,074	520.0	4,009	61,539
525.0	5,084	102,666	525.0	4,673	84,011
530.0	5,696	129,082	530.0	5,365	108,508
535.0[3]	6,707	159,230	535.0[3]	6,707	137,930

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 RCWP and annual sedimentation rate of 426 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-2. Lake Ray Roberts Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 Sediment Conditions		
Elevation (ft-msl)	Area (acres)	Capacity (acft)	Elevation (ft-msl)	Area (acres)	Capacity (acft)
542.0	0	0	542.0	0	0
551.0[2]	57	162	551.0[2]	0	0
560.0	1,215	6,649	560.0	857	4,014
570.0	3,091	25,630	570.0	2,491	19,034
580.0	5,328	65,253	580.0	4,669	52,279
590.0	7,168	108,827	590.0	6,469	89,155
600.0	10,931	202,573	600.0	10,235	175,928
610.0	14,681	331,174	610.0	14,027	297,799
620.0	19,481	473,578	620.0	18,923	434,095
630.0	27,806	722,341	630.0	27,530	678,606
632.5[3]	28,983	781,264	632.5[3]	28,983	737,252

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 RCWP and annual sedimentation rate of 880 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-3. Lake Lewisville Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 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	36	155	465.0	0	0
470.0	244	1,452	470.0	0	0
475.0	2,120	12,524	475.0	1,042	6,944
480.0	3,898	29,108	480.0	2,292	17,629
481.0[2]	4,208	33,844	481.0[2]	2,588	20,720
485.0	5,449	52,788	485.0	3,771	33,080
490.0	7,223	84,881	490.0	5,504	56,773
495.0	9,258	126,850	495.0	7,535	90,140
500.0	11,547	179,379	500.0	9,864	134,265
505.0	14,092	242,468	505.0	12,490	189,147
510.0	17,421	322,592	510.0	15,984	261,897
515.0	21,535	419,751	515.0	20,345	352,515
520.0	25,654	538,347	520.0	25,188	467,041
522.0[3]	27,304	593,700	522.0[3]	27,304	521,680

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 RCWP and annual sedimentation rate of 1,440 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-4. Lake Palestine Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 Sediment Conditions		
Elevation (ft-msl)	Area (acres)	Capacity (acft)	Elevation (ft-msl)	Area (acres)	Capacity (acft)
295.0	0	0	295.0	0	0
298.0	10	19	298.0	0	0
300.0	17	32	300.0	0	0
305.0	42	189	305.0	0	0
309.5[2]	813	2,811	309.5[2]	375	1,212
315.0	2,580	13,075	315.0	1,638	7,772
320.0	4,808	29,145	320.0	3,485	18,690
325.0	8,071	62,907	325.0	6,365	44,747
330.0	11,469	115,785	330.0	9,481	88,255
335.0	14,942	186,710	335.0	12,812	148,732
340.0	18,476	262,529	340.0	16,383	214,360
345.0[3]	22,705	365,192	345.0[3]	22,705	309,213

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 Region I Water Plan and annual sedimentation rate of 1,120 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-5. Lake Ray Hubbard Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 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[2]	1,274	3,159	396.0[2]	0	0
400.0	2,981	12,064	400.0	686	1,286
405.0	5,801	34,584	405.0	3,093	11,307
410.0	8,186	69,946	410.0	5,686	33,655
415.0	10,597	117,031	415.0	8,638	69,625
420.0	13,075	176,247	420.0	11,799	120,823
425.0	15,485	247,435	425.0	14,851	187,337
430.0	18,344	331,584	430.0	18,156	269,552
435.0	20,843	434,293	435.0	20,833	371,820
435.5[3]	21,075	445,094	435.5[3]	21,075	382,606

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 RCWP and annual sedimentation rate of 1,250 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-6. Lake Tawakoni Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 Sediment Conditions		
Elevation (ft-msl)	Area (acres)	Capacity (acft)	Elevation (ft-msl)	Area (acres)	Capacity (acft)
373.0	0	0	373.0	0	0
380.0	422	316	380.0	0	0
390.0	2,751	7,690	390.0	1,510	3,293
391.0[2]	3,338	11,565	391.0[2]	2,069	5,874
400.0	8,889	68,351	400.0	7,430	50,240
410.0	14,794	182,011	410.0	13,247	148,877
420.0	21,770	365,420	420.0	20,296	317,077
430.0	29,998	618,531	430.0	28,834	556,755
437.5[3]	37,851	872,279	437.5[3]	37,851	807,329

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 Region D Water Plan and annual sedimentation rate of 1,299 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

Table H-7. Lake Fork Elevation-Area-Capacity Relationships for 2020 and 2070 Sediment Conditions[1]

Units: as shown in table

2020 Sediment Conditions			2070 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	1,109	3,192	350.0	56	161
355.0	2,385	12,080	355.0	550	1,896
360.0[2]	3,876	27,072	360.0[2]	1,893	7,347
365.0	5,674	52,773	365.0	3,599	22,838
370.0	7,610	84,157	370.0	5,469	43,770
375.0	9,793	127,564	375.0	7,636	76,431
380.0	12,259	184,207	380.0	10,142	122,436
385.0	14,964	254,507	385.0	12,957	182,671
390.0	17,923	340,328	390.0	16,108	259,248
395.0	20,881	426,149	395.0	19,259	335,825
400.0	24,870	545,558	400.0	24,262	452,530
403.0[3]	27,264	617,203	403.0[3]	27,264	522,553

[1]Estimated on basis of 2010 and 2060 elevation-area-capacity relationships used in the 2011 Region D Water Plan and annual sedimentation rate of 1,893 acft/yr.
[2]Top of Dead Pool Storage
[3]Top of Conservation Pool

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Appendix I

Climate Change Model Projections and Associated Changes in Reservoir Evaporation

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HDR | ONE COMPANY *Many Solutions*℠

To:	File		
From:	Cory Shockley, P.E. Ken Choffel, P.E. Zach Stein, P.E. Christian Braneon, EIT	Re:	Application of GCM Temperature Changes to Dallas LRWSP Modeling
CC:			
Date:	February 6, 2013		

Projected Daily Maximum Temperature Change Resulting from Climate Change Applied to Reservoir Evaporation in the Dallas Long Range Water Supply Plan Surface Water Supply Modeling Assumptions

Background

Climate change is expected to lead to an increase in surface air temperatures in Northeast Texas and many other regions of the world during the 21st century (IPCC, 2007; Jiang and Yang, 2012). This increase in temperature will lead to an increase in reservoir evaporation. The increased evaporation associated with climate change will reduce reservoir yields and consequently reduce surface water availability (Seager et al., 2012). Thus, an estimate of projected reservoir evaporation considering climate change is critical to updating reservoir yields (Hutchison, 2008; Jackson, 2008; Lowe et al., 2009).

As part of the work on the integrated pipeline project (IPL) betweenThe Tarrant Regional Water District (TRWD) and Dallas Water Utilities (Dallas), regression equations were developed that describe the relationship between cumulative estimated gross pan evaporation and monthly average daily maximum temperature (IPL Technical Memo No. 5, 2010). These regression equations are utilized along with projections of increased daily maximum temperature derived from eight global climate models (also known as general circulation models, GCMs) in order to estimate an average evaporation rate increase for selected decadal points in the planning horizon (i.e. 2010, 2030, 2050, and 2070). This memorandum describes the methods used to estimate changes in daily maximum temperature utilizing GCM projections of projected surface air temperature for the purpose of determining increased reservoir evaporation for use in the surface water modeling scenarios to be included in the Dallas Long Range Water Supply Plan (LRWSP).

In summary, this memorandum includes:

- Discussion of evaporation estimation methods;
- Discussion of GCMs and downscaling approach;
- Development of projected increases in temperature due to climate change;
- Summary of findings and recommendation for selection of appropriate temperature changes to estimate gross pan evaporation.

Estimation of Reservoir Evaporation

Methods for the estimation of reservoir evaporation include the water budget method, energy budget method, eddy-correlation method, mass-transfer approach, the Penman method, combination equation, and the pan coefficient method (Dingman, 1994). In addition, methods that require remote sensing data may be utilized to estimate reservoir evaporation when quality data is available at a useful temporal resolution (e.g. Guerschman et al., 2009). Most of the methods listed above require meteorological variables (e.g. vapor pressure, humidity, or wind velocity) that are not typically available at water supply reservoirs. Thus, the pan coefficient method is the most commonly used and proven technique for water resources applications because it may be applied with minimal data requirements (Bras, 1990; Lowe et al., 2009).

Relationships between daily maximum temperature and monthly gross pan evaporation may be utilized to estimate reservoir evaporation in regions where historical daily maximum temperature and pan evaporation data is available. In West Texas, regression equations have been developed to estimate monthly and annual reservoir evaporation from maximum temperature data for climate change assessment applications (North, 2008). In Northeast Texas, TRWD and Dallas have also utilized regression equations to estimate reservoir evaporation in order to project future evaporation conditions (IPL Technical Memo No. 5, 2010). These equations were applied with projections of surface air temperature derived from GCMs in order to estimate the increased evaporation rates in Northeast Texas that are associated with a changing climate.

Climate Change Assessments with GCM Projections

Projections of climate change are based on GCMs, which are complex computer programs that that are based on our current understanding of the coupled atmospheric and oceanic processes that govern the Earth's climate (Zhang and Georgakakos, 2011). The 2007 report of the Intergovernmental Panel on Climate Change (IPCC) indicates that these models suggest that global average surface temperatures are likely to rise from 3°F to 7°F by the year 2099 (SECC, 2008). In order to apply GCM outputs for water resource applications, the gridded output from the models must be spatially downscaled from their coarse spatial resolution (i.e. 5,776 to 122,500 mi^2) to spatial scales (i.e. 1/16 to 1/2 degree over U.S. latitudes) useful for regional assessments (Daniels et al., 2012).

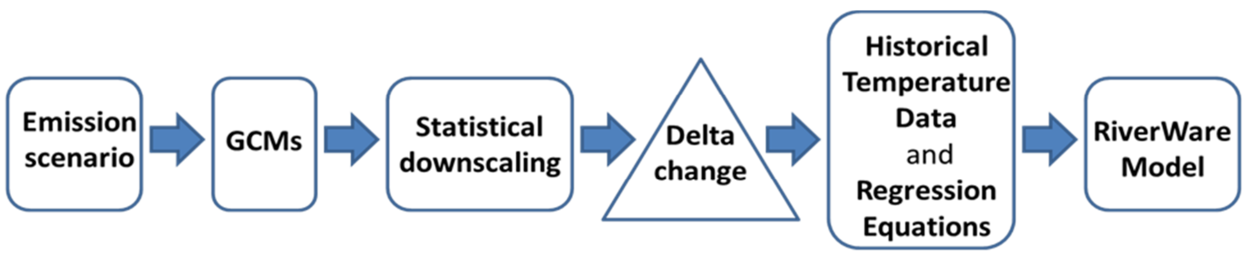

Figure 1. Schematic depicting the development of projected increases in temperature due to climate change and related changes to evaporation estimates for RiverWare model.

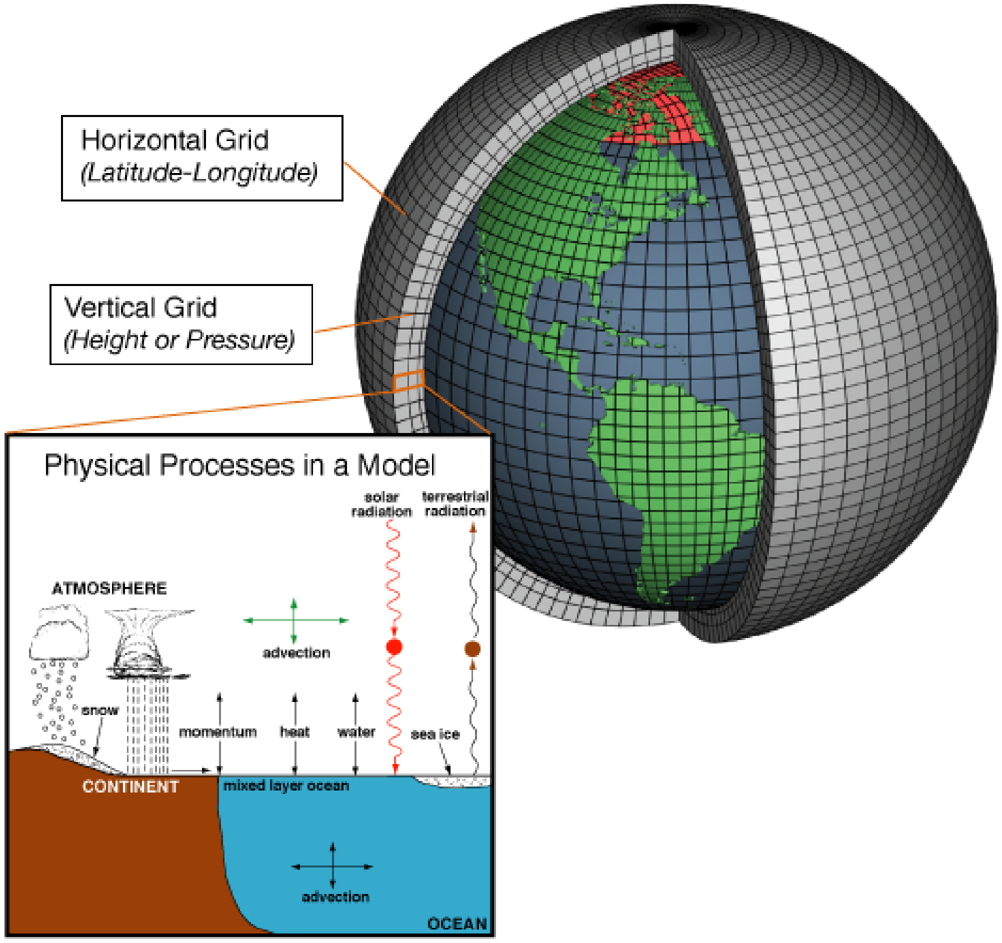

Figure 2. Schematic of a global climate model (GCM) illustrating the physical processes modeled within the model grid* (NOAA, 2012)*.

Development of Projected Daily Maximum Temperatures

For estimation of increased evaporation rates from water supply reservoirs in Northeast Texas, GCM model outputs that have been spatially downscaled were utilized. Statistically downscaled climate projections (i.e. daily maximum temperature at 1/8 degree) provided by the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model data set are available for a baseline (also called "current") simulation time period (1961-2000) as well as future time periods (2046-2065 and 2081-2100). All eight GCMs that currently have outputs available at daily resolution were utilized to derive multi-model mean estimates (i.e. the ensemble mean) of average monthly maximum temperature. Each GCM is equally weighted to derive mean temperature estimates under the A1B CO_2 emissions scenario (Hidalgo, et al. 2007; Meehl et al., 2007; Maurer and Hidalgo, 2008; Maurer et al., 2010). Downscaled maximum temperature data at individual 1/8 degree cells in the Dallas area (32.1875 to 33.4375 ° N, 97.0625 to 95.4375 ° W) are aggregated to determine the overall spatial mean. This area encompasses the pertinent reservoirs that are critical for Dallas' water supply system.

In the "delta approach" (or change factor approach), the difference between future (e.g. 2046-2065) and current (e.g. 1961-2000) mean GCM temperatures, called the delta (Δ) or change factor, is calculated and added to observed weather data in order to construct future climate conditions.This approach is commonly utilized for climate change assessments and an additive shift is deemed most appropriate for utilizing GCM outputs to modify observed mean local temperature (Tidwell, 2006; Hayhoe, 2010; Horton et al., 2011).

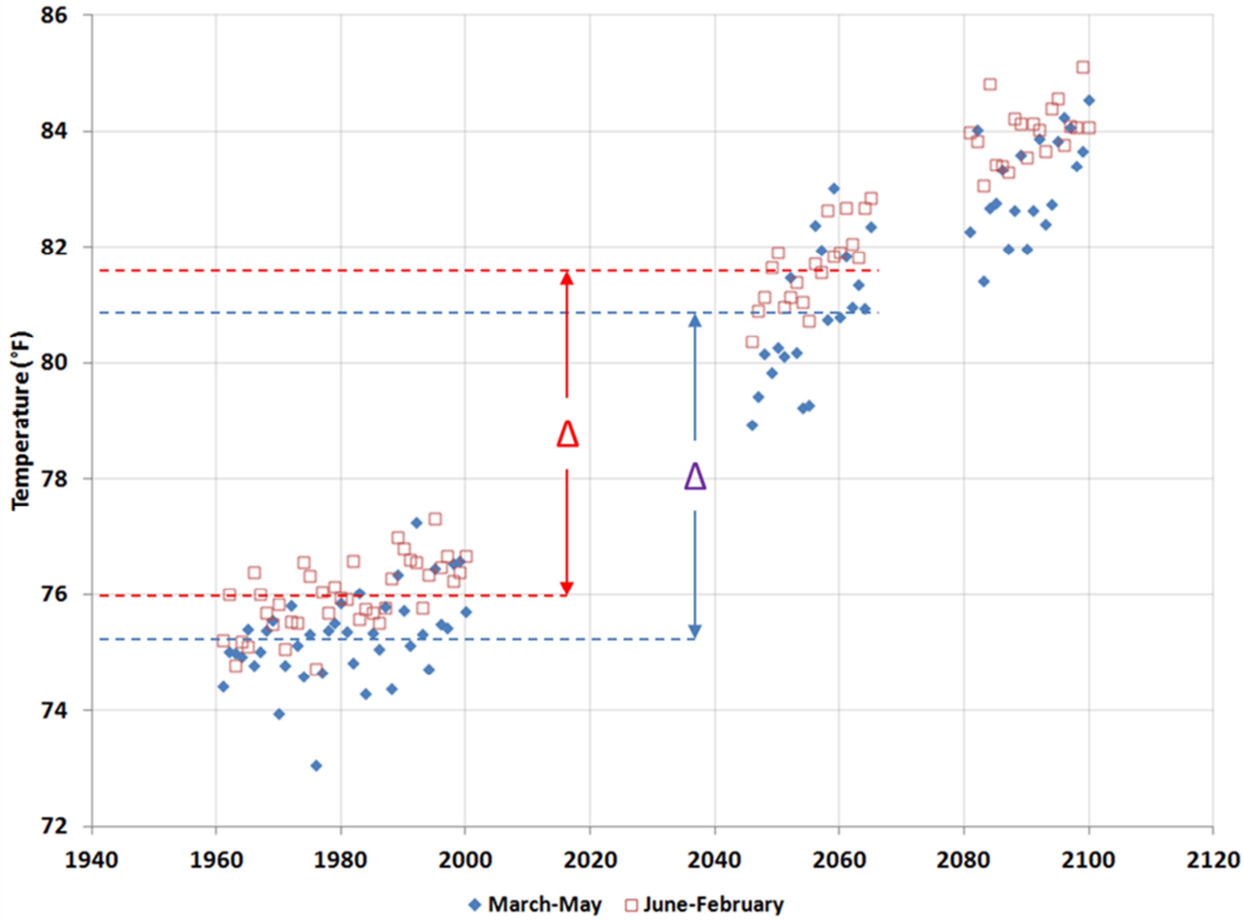

Figure 3. Schematic of the delta approach applied to determine temperature change factors from mean GCM temperature data (1961-2000 and 2046-2065 time periods) for March-May (shown in blue) and June-February (shown in red).

This method assumes that changes in long-term averages can be applied uniformly to all time periods of interest (Daniels et al., 2012). The 2050 estimate of future temperature change is obtained from the nine year (i.e. 2046-2054) moving average of projected temperatures centered on the year 2050. Estimates of 2010 and 2030 temperature changes are obtained through linear interpolation of the baseline mean temperature and the 2050 estimated temperature. Finally, the 2070 estimate of future temperature change is obtained through linear interpolation of the projected temperature changes for the 2046-2065 and 2081-2100 time periods.

Recommendations for Estimating Reservoir Evaporation under Climate Change

To estimate potential increases in reservoir evaporation resulting from increased temperatures due to climate change, temperature change factors (see Table 1) are presented below that are derived from WRCP GCM projections of current (i.e. 1961-2000) and future daily maximum temperature in the Northeast Texas area with the delta approach. The temperature change factors are utilized with historical data (i.e. NCDC monthly average of daily maximum temperatures) in the area to project future maximum daily temperature by adding the estimated temperature change factors uniformly to the data in the historical time period. Each temperature change factor represents a plausible future climate scenario that may be utilized for water supply planning purposes. The relationships between monthly gross pan evaporation and average monthly maximum temperature developed previously (see Figure 3 below) during the development of the Dallas Riverware Model are then applied to determine projected lake evaporation in the future under climate change (IPL Technical Memo No. 5, 2010).

Year	March - May	June - February
	Δ Temperature (°F)	Δ Temperature (°F)
2010	1	1
2030	3	3
2050	5	5
2070	7	7

Table 1. Change factors derived from GCM data for lake evaporation estimates. All values are rounded to the nearest degree (°F).

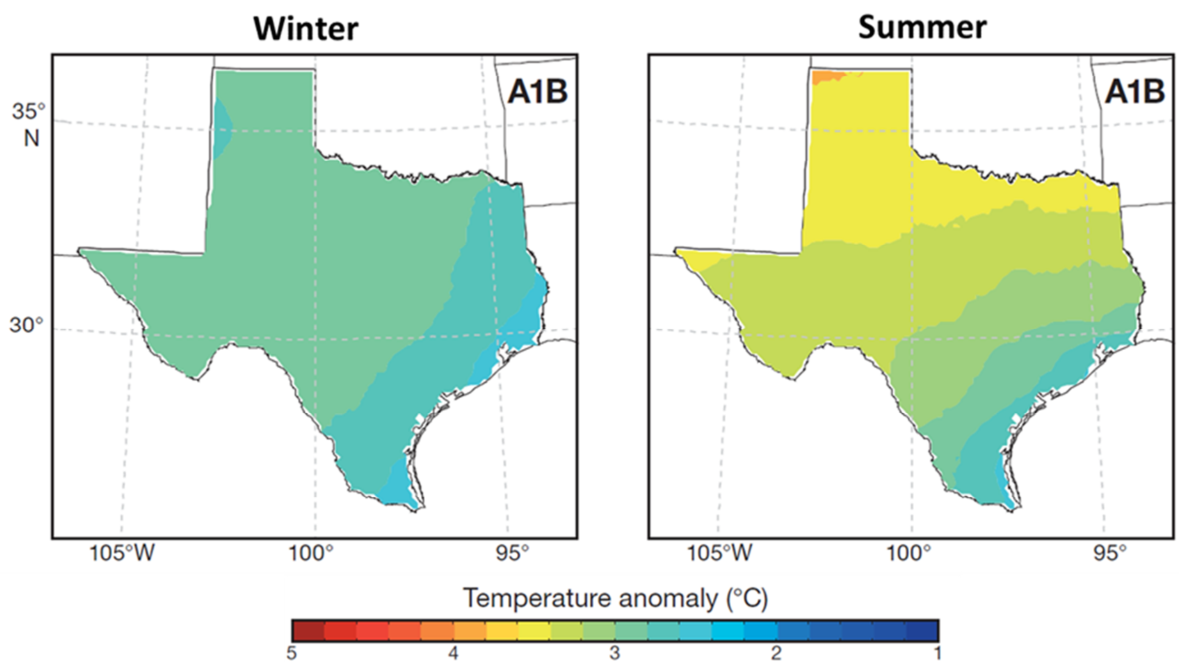

***Figure 4. Projected winter (Dec-Jan-Feb) and summer (Jun-Jul-Aug) mean surface air temperature changes (°C) between 2070−2099 and 1971−2000 under the A1B emissions scenario* (adapted from Jiang and Yang, 2012).**

Spring Months (March-May)

$E = 0.8555*\exp(0.0271*T)$

E = Monthly Gross Pan Evaporation (in)

T = Monthly Average of Daily High Temperatures (°F)

All Remaining Months (June-February)

$E = 0.4022*\exp(0.0340*T)$

E = Monthly Gross Pan Evaporation (in)

T = Monthly Average of Daily High Temperatures (°F)

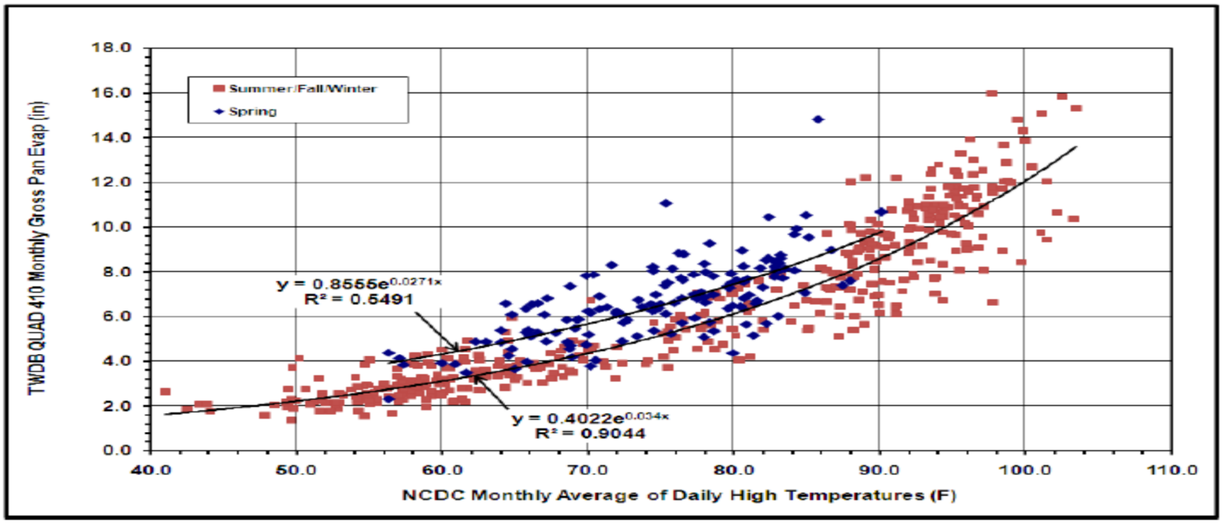

Figure 15. Comparison of Regression Equations for Spring Months and All Other Months

Figure 5. Comparison of regression equations for Spring months (March, April and May) and all other months **(IPL Technical Memo No. 5, 2010).**

Appendix J

Adopted City Council Resolution Authorizing DWU Staff to Include Recommended and Alternative Strategies in the 2014 LRWSP

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WHEREAS, on September 26, 2012 the City Council authorized a contract with HDR Engineering, Inc. to prepare the City's Long Range Water Supply Plan (the Plan) to the year 2070 and beyond; and,

WHEREAS, on April 10, 2013, the City Council approved the City's participation in the Sulphur River Basin Wide Study and Neches River Basin Study; and,

WHEREAS, the Plan identified reductions in demands due to a decline in the rate of population growth and the reduction in the per capita water usage, due to substantial water savings from Dallas' water conservation programs as identified in Dallas' Water Conservation Five-Year Strategic Plan including time of day watering and maximum twice weekly outdoor watering; and,

WHEREAS, the Plan identified a reduction in the currently connected water supply due to sedimentation and the projected increase in evaporation due to increased temperatures associated with climate change over the 55 year planning horizon; and,

WHEREAS, comparing the water demands with the currently connected water supply by decade the City's projected water needs were identified and the City needs to obtain and connect additional water supply in order to meet the future needs of the citizens and customers of Dallas; and,

WHEREAS, to meet the projected water needs the Plan identified over 300 possible strategies and through a multi level screening process identified 41 Potential Strategies that were further analyzed and narrowed down to a list of 14 Preferred Strategies; and,

WHEREAS, seven of the top nine ranked Preferred Strategies were then selected as Recommended Strategies to meet Dallas' water needs to 2070 and beyond; and,

WHEREAS, the Recommended Strategies are additional water conservation, indirect reuse implementation (main stem pump station and main stem balancing reservoir), connection of the Integrated Pipeline Project to connect Lake Palestine (including the connection to the Bachman Water Treatment Plant) and additional water from the Neches River and Lake Columbia; and,

WHEREAS, the remaining seven of the 14 Preferred Strategies were identified as Alternate Strategies; and,

WHEREAS, the Alternate Strategies are direct reuse, Carrizo Wilcox groundwater, off-channel reservoir and Carrizo Wilcox groundwater from the Sabine River Basin, Red River off-channel reservoir, Sulphur River Basin water from Wright Patman and Marvin Nichols, Toledo Bend and Lake Texoma desalination; and,

WHEREAS, the Plan identified infrastructure improvements needed as a result of growth, anticipated regulation changes and reliability, and water treatment plant modifications and expansions, distribution system enhancements and raw water transmission modifications and enhancements; and,

WHEREAS, the Recommended Strategies and Alternate Strategies are required to be submitted to the Region C Water Planning Group for inclusion into the 2016 Region C Water Plan and the 2017 State Water Plan prior to January 2015.

Now, Therefore,

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF DALLAS:

Section 1. That the Recommended Strategies, Alternate Strategies and the Infrastructure Recommendations identified in the City of Dallas 2014 Long Range Water Supply Plan are hereby adopted as shown on Exhibit A.

Section 2. That the City Manager be directed to submit Exhibit A for the City of Dallas to the Region C Water Planning Group.

Section 3. That this resolution shall take effect immediately from and after its passage in accordance with the provisions of the Charter of Dallas, and it is accordingly so resolved.

APPROVED BY
CITY COUNCIL

OCT 08 2014

City Secretary

Water Supply Strategies

Strategy	Date	Supply (MGD)
Conservation (savings)	2020	11.0
	2030	25.0
	2040	37.0
	2050	43.0
	2060	45.0
	2070	47.0
Indirect Reuse Implementation		
Main Stem Pump Station (NTMWD Swap Agreement)	2020	31.0
Main Stem Balancing Reservoir	2050	75.0
	2060	91.0
	2070	102.0
Connect Existing Supplies		
Lake Palestine (Integrated Pipeline Project)	2030	102.0
IPL Connection to Palestine		
IPL Connection to Bachman WTP		
Neches Run-of-River	2060	40.0
Lake Columbia	2070	50.0

Alternative Supply Recommendations

Direct Reuse Alternative 1
Carrizo Wilcox Groundwater 2
Sabine Conjunctive Sys Ops (Off Channel Reservoir and Groundwater)
Red River Off Channel Reservoir 1
Wright Patman (232.5)/Marvin Nichols (296.5)
Toledo Bend to West System
Lake Texoma Desalinization

Exhibit A

Infrastructure

Project	Drivers	Recommended Implementation
Elm Fork WTP Pre-sedimentation Basin	G / R	2017
East Side WTP WQI	G / R / M	2018
72-inch Treated Water Pipeline (Bachman WTP to Elm Fork WTP)	G / R / M	2018
Elm Fork WTP Residuals Handling Improvements	G / R / M	2018
Elm Fork WTP Pump Station 1	R / M	2018
Iron Bridge Pump Station Rehab	R / M	2018
East Side WTP Residuals Basins and Sludge PS Improvements	M	2022
Elm Fork WTP WQI6	G / R / M	2024
144-in Pipeline (from Tawakoni Interconnect to Balancing Reservoir and on to East Side WTP)	G / M	2030
Wintergreen Pump Station and Southwest Pipelines	G	2030
Tawakoni Balancing Reservoir Expansion	G / M	2030
East Side WTP Electrical Distribution System Improvements and Substation 3	G / M	2030
East Side WTP Stage V Filters	G / R	2030
Western WTP Expansion	G	2045

Drivers:

G – Growth
R – Regulatory
M – Maintenance/Reliability

Appendix K

Recommended and Alternative Strategy Fact Sheets

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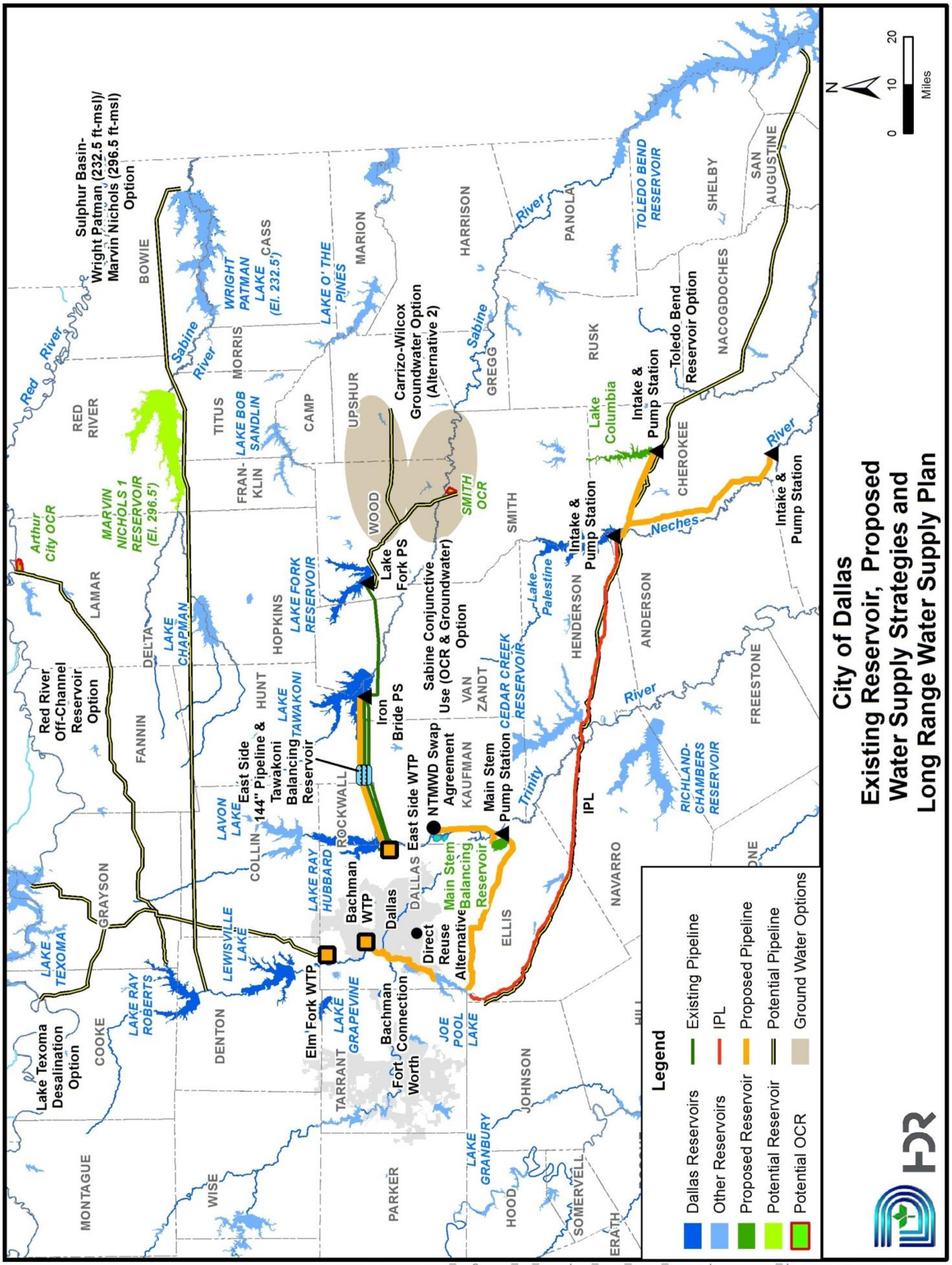
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES

Table K-1. Recommended and Alternative Strategy Characteristic Summary

Description			Environmental Impacts (Qualitative Assessment - Level of Concern)						Dallas Portion of Cost (if shared or regional project)			
Strategy	Selection	Supply (MGD)	Habitat	Env. Water Needs	Bay and Estuary	Threatened and Endangered	Wetland	Agriculture and Natural Resources	Total Project ($ Millions)	Annual ($ Millions)	Unit ($/acft)	Unit ($/1,000 gal)
Additional Conservation	Rec.	46.4	None	None	None	None	None	None	51.7 [b]	$6.44	$124.00	$0.38
Main Stem Pump Station - NTMWD Swap Agreement	Rec.	31.1	Low	Low	Low	Low	Low	Low	$26.11	$2.88	$83	$0.25
Main Stem Balancing Reservoir	Rec.	102	Low	Low	Low	Low	Low	Low	$674.46	$64.89	$568	$1.74
IPL Part 1 - Connection to Lake Palestine	Rec.	102 [a]	Low	Low	Low	Low	Low	Low	$938.95	$85.90	$751	$2.31
IPL Part 2 - Connection to Bachman WTP	Rec.	102 [a]	Low	None	None	Low	Low	Low	$244.32	$18.20	$159	$0.49
Neches Run of River	Rec.	42	Low	Low	Low	Low	Low	Low	$226.79	$28.97	$613	$1.88
Lake Columbia	Rec.	50	High	Medium-High	Low	Low	High	Low	$288.64	$32.55	$581	$1.78
Direct Reuse - Alternative 1	Alt.	2.2	None	None	None	Low	None	None	$27.43	$1.83	$731	$2.24
Carrizo Wilcox Groundwater (Alternative 2)	Alt.	27	Low	None	None	Low	Low	Low	$161.06	$17.61	$587	$1.80
Sabine - Conjunctive Use (OCR and groundwater)	Alt.	93	Low	Low	Low	Low	Low	Low	$795.82	$77.12	$740	$2.27
Red River OCR	Alt.	102	Low	Low	Low	Low	Low	Low	$852.99	$84.19	$738	$2.27
Sulphur Basin - Wright Patman (232.5) / Marvin Nichols (296.5)	Alt.	102	High	Medium-High	low	Medium	High	Medium	$1,003.14	$84.64	$742	$2.28
Toledo Bend Reservoir	Alt.	178	Medium	Medium	Medium	Low	Low	Low	$2,290.07	$204.71	$1,024	$3.14
Lake Texoma Desalination	Alt.	130	Low	Low-Medium	Low	Low	Low	Low	$1,382.14	$168.41	$1,153	$3.54

[a] Both IPL Part 1 and Part 2 are required for Dallas to obtain the 102 MGD supply.

[b] Calculated equivalent total project cost using a net present value analysis, see Section 7.2.6 for detail.



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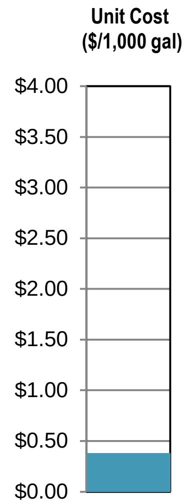
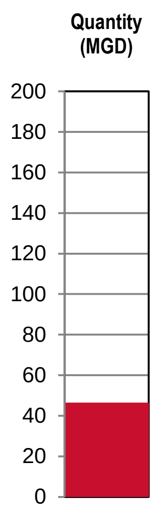
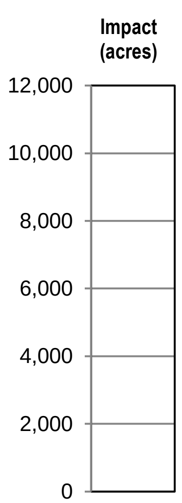
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Additional Water Conservation**

Status: **Recommended (2020)**

Description of Strategy:

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)). Conserving existing water supplies through demand reduction can be one of the most cost-effective strategies available to municipal water suppliers to increase available supply. Conservation goals applicable over the 50-year planning timeframe of the 2014 LRWSP and ideas on how these goals could potentially be met through strategies are identified in Dallas’ Strategic Plan and Water Conservation Plan. Additional water conservation is the conservation that is anticipated to be achieved above the water savings associated with the plumbing fixtures act.

Water Availability:

The annual volume of water saved under the additional conservation savings strategy is estimated to be 10.9 MGD in 2020 (12,219 acft/year) and 46.4 MGD in 2070 (52,014 acft/year). This represents a potential additional reduction in water use by the City of Dallas of 4.4% in 2020 and 12.9% in 2070 as compared to the TWDB’s baseline projections.

Permitting and Environmental Issues:

Permitting and environmental issues are minimal for additional water conservation.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water:	$0.38	$/1,000 gal	Treated Water Delivered
Quantity of Water:	46.4	MGD	Reliability = Firm

Phasing and Implementation:

Dallas continues to actively improve its water conservation efforts with the recent adoption of an update to its water conservation plan and the planned update of their strategic water conservation plan. These documents guide and document how Dallas plans, achieves, and monitors savings from conservation. The biggest risk to achieving the supply savings associated with additional conservation is the ability to continue to modify consumer behavior. Achieving additional conservation savings becomes more challenging as these savings are realized. Generally, easier programs are implemented first with more advanced programs that are more costly or require a greater level of consumer behavior modification implemented next. To overcome these risks, Dallas should continue to invest resources in the update to its strategic water conservation plan and continue to identify and implement best management practices that are likely to succeed as technology improves and consumer behaviors change.

Additional Conservation Implementation Steps:

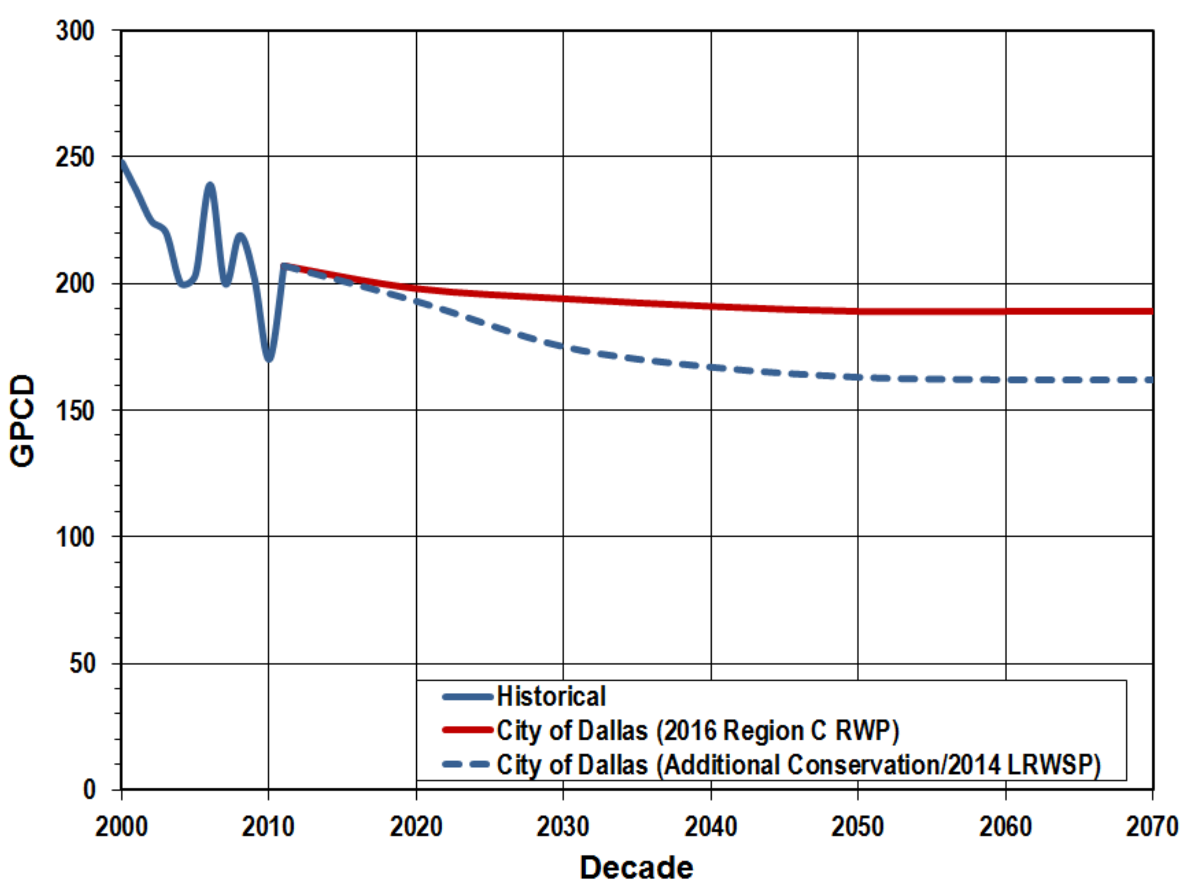
- Update Water Conservation Five-Year Strategic Plan to identify, fund and implement appropriate best management practices to achieve the planned savings.
- Continue to monitor and document savings achieved from conservation efforts.

Estimated Reduction Dallas Water Demands with Additional Conservation Strategy

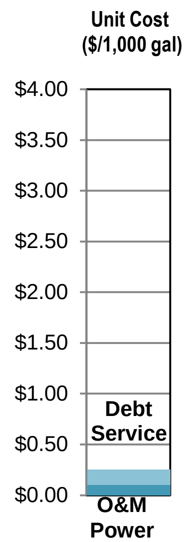
Component	2020	2030	2040	2050	2060	2070
Dallas Population Projections	1,242,135	1,347,717	1,531,681	1,707,057	1,841,064	1,905,498
TWDB Projected gpcd **(2011 TWDB baseline = 207 gpcd)**	198	194	191	189	189	189
TWDB Projected Water Demand (MGD)	245.6	260.8	291.6	322.5	347.2	359.3
Recommended gpcd with Additional Conservation (2014 LRWSP)	189	175	167	164	164	164
Projected Water Demand w/ Additional Conservation – (MGD)	234.7	236.2	255.3	280.3	302.3	312.9
Additional Conservation Savings (MGD)	10.9	24.6	36.3	42.2	44.9	46.4
Percentage Decrease in Water Demand with Additional Conservation	4.4%	9.5%	12.4%	13.1%	12.9%	12.9%

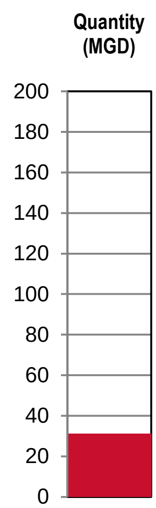
Note: The TWDB established a per capita use of 207 gpcd for Dallas for the year 2011 which serves as the baseline value for determining the estimated reductions presented in this table. Values in the table are rounded to the nearest 0.1 MGD.

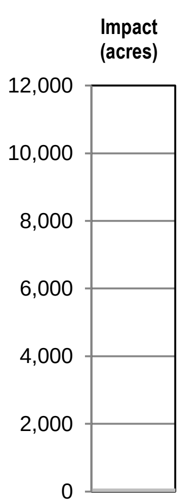
Comparison of Per Capita Water Use Goals for the City of Dallas



RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Main Stem Pump Station**

Status: **Recommended (2020)**

Cost Summary (Dallas Portion)	
Total Project Cost	**$26.1 M**
Annual Debt Service	$1.8 M
Annual O&M and Power	$1.1 M
Total Annual Cost	**$2.9 M**

Description of Strategy:

In December 2008, Dallas and the North Texas Municipal Water District (NTMWD) entered into an agreement (swap 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. Under the swap agreement Dallas and NTMWD will cooperate in the construction of a pump station (Main Stem Pump Station) and transmission pipeline to deliver up to 90 MGD of return flows (from Dallas and other entities) from a location on the main stem of the Trinity River to an agreed "point of delivery" near the NTMWD wetlands located near the East Fork of the Trinity River and Hwy 175 near Seagoville. Upon completion of the Main Stem Pump Station and pipeline, Dallas will have the right to utilize all of NTMWD water discharged into Lake Ray Hubbard. The project to be constructed under the swap agreement includes the construction of a Main Stem Pump Station (90 MGD) and a 72-inch diameter, 14.2 mile pipeline to transport water to the NTMWD wetlands

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. By 2040 the volume of NTMWD return flows discharged into Lake Ray Hubbard is estimated to total 31.1 MGD (34,863 acft/yr).

Permitting and Environmental Issues:

Dallas has a water right permit that allows for the diversion of Dallas' return flows from the Trinity River. Therefore the only significant permit required for the construction of the Main Stem Pump Station project would be a Section 404 permit from the USACE for impacts to a waterway associated with the construction of the diversion facilities and pipeline. Additionally, if it were necessary to construct a new channel dam on the Trinity River, then this structure would require a new state water rights permit and need to be considered in the Section 404 permitting process.

Environmental concerns associated with the main stem pump station project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

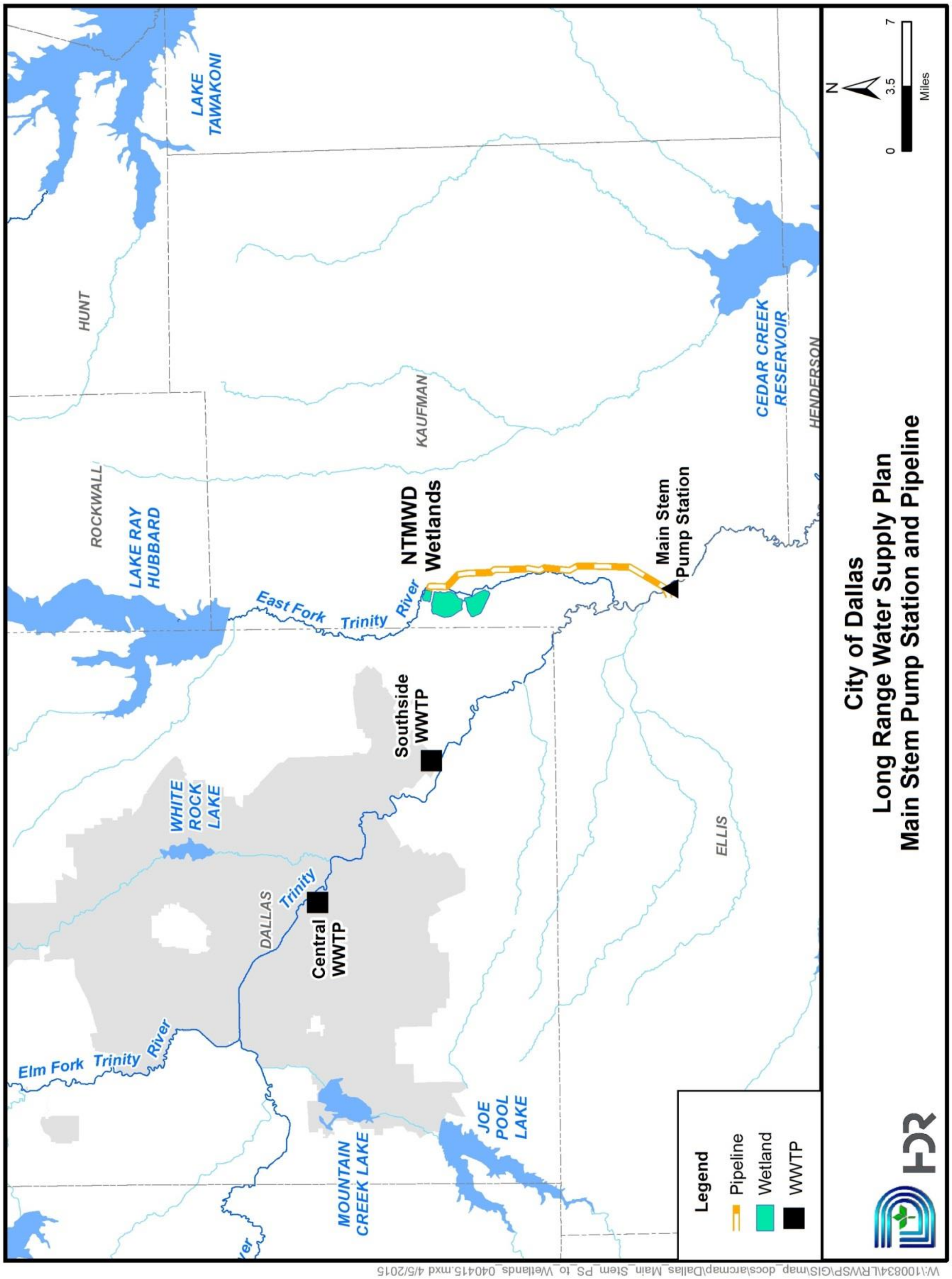
Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$0.25 $0.10	$/1,000 gal	Raw water in Lake Ray Hubbard
Quantity of Water:	31.1	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	91	acres	

Phasing and Implementation:

The following implementation steps are recommended for the Main Stem Pump Station.

- Continue to coordinate with NTMWD on the implementation of this strategy.
- Because the project timeline has shifted due to the immediate need of NTMWD, Dallas and NTMWD are planning to amend the terms of the swap agreement to reflect the new concept and timeline.


City of Dallas
Long Range Water Supply Plan
Main Stem Pump Station and Pipeline
Legend
Pipeline
Wetland
WWTP
NTMWD Wetlands
Main Stem Pump Station
Southside WWTP
Central WWTP
LAKE TAWAKONI
LAKE RAY HUBBARD
WHITE ROCK LAKE
JOE POOL LAKE
MOUNTAIN CREEK LAKE
CEDAR CREEK RESERVOIR
East Fork Trinity River
Elm Fork Trinity River
Trinity
HUNT
ROCKWALL
KAUFMAN
DALLAS
ELLIS
HENDERSON
N
0
3.5
7
Miles
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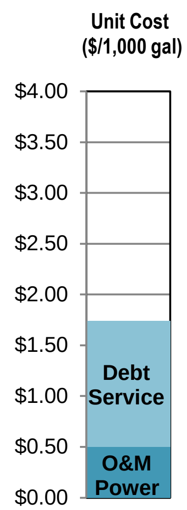
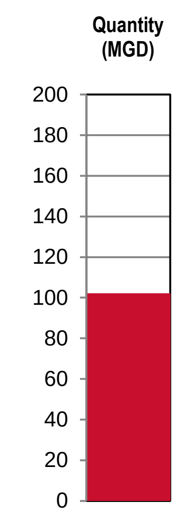
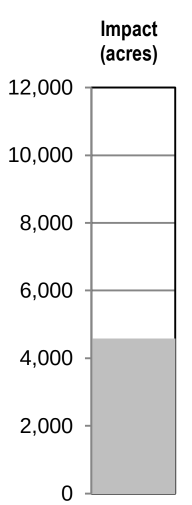
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Main Stem Balancing Reservoir**

Status: **Recommended (2050)**

Cost Summary	
Total Project Cost	**$674.5 M**
Annual Debt Service	$46.4 M
Annual O&M and Power	$18.5 M
Total Annual Cost	**$64.9 M**

Description of Strategy:

The Main Stem Balancing Reservoir project is a proposed off channel reservoir that could store approximately 300,000 acft of Dallas' (and potentially other entities') return flows as well as stormwater runoff originating in the upstream Trinity River watershed. Additionally, because the diversion point for this strategy is located downstream of the confluence with the East Fork of the Trinity River, 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. Water supplies would be delivered to the Joe Pool area through a 36.5 mile, 84-inch transmission system.

Water Availability:

The Main Stem Balancing Reservoir was preliminarily designed to achieve a desired firm yield of 102 MGD (114,000 acft/yr) by 2070. The water availability analysis indicated that by 2070, 109 MGD of return flows would be available for diversion after considering the swap agreement with NTMWD and an amended instream flow requirement.

Permitting and Environmental Issues:

This project would require a surface water permit for the channel dam (if needed) on the Trinity River 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.

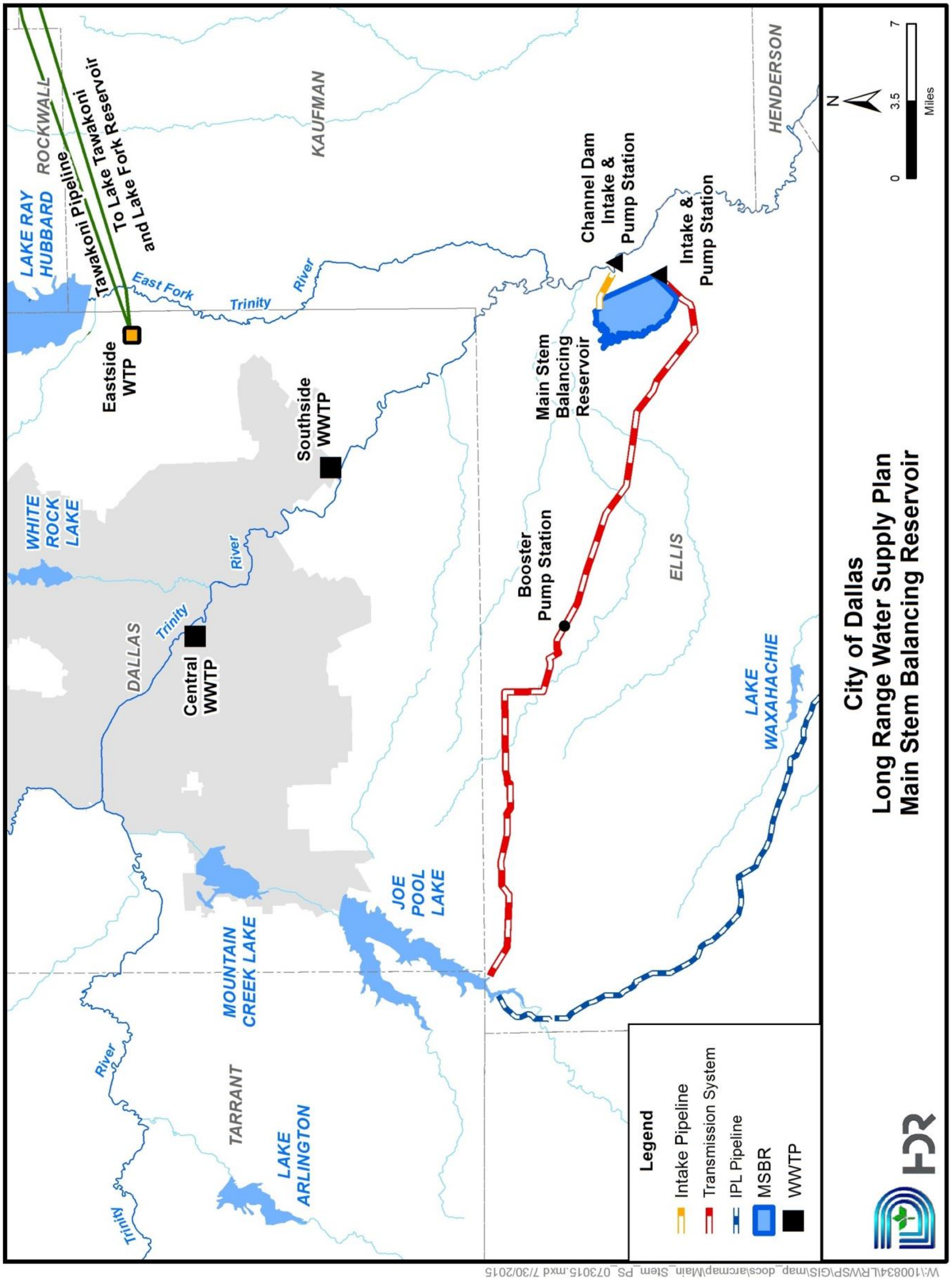
Environmental concerns associated with the main stem pump station project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$1.74 $0.50	$/1,000 gal	Raw Water Delivered to Bachman Turnout / Joe Pool Area
Quantity of Water:	102	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	4,584	acres	

Phasing and Implementation:

It is recommended that Dallas initiate a feasibility study that includes: securing the water rights permit for the storage reservoir, performing a reservoir site foundation evaluation, initiating a land acquisition and maintenance program (prior to construction), preparing a water quality evaluation, performing a siting study of the main-stem pump station considering flooding issues; and determining the need for a new Trinity River water control structure or improvements to an existing structure.


City of Dallas
Long Range Water Supply Plan
Main Stem Balancing Reservoir
LAKE RAY HUBBARD
ROCKWALL
Tawakoni Pipeline
To Lake Tawakoni and Lake Fork Reservoir
KAUFMAN
HENDERSON
Channel Dam Intake & Pump Station
Intake & Pump Station
Eastside WTP
East Fork
Trinity
River
Main Stem Balancing Reservoir
Southside WWTP
WHITE ROCK LAKE
Booster Pump Station
ELLIS
DALLAS
Central WWTP
LAKE WAXAHACHIE
JOE POOL LAKE
MOUNTAIN CREEK LAKE
TARRANT
LAKE ARLINGTON
Legend
Intake Pipeline
Transmission System
IPL Pipeline
MSBR
WWTP
N
0
3.5
7
Miles
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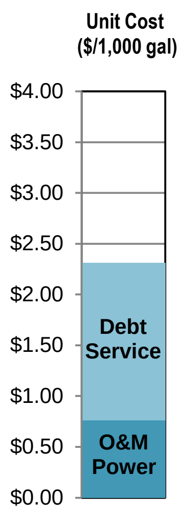
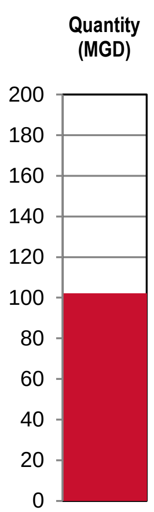
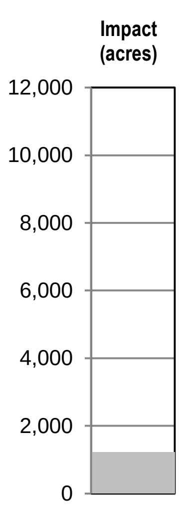
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Integrated Pipeline (IPL) – Part 1 Connection to Lake Palestine**

Status: **Recommended (2027)**

Cost Summary	
Total Project Cost	**$939 M**
Annual Debt Service	$64.6 M
Annual O&M and Power	$21.3 M
Total Annual Cost	**$85.9 M**

Description of Strategy:

Dallas and the TRWD are partnering on the planning and development of an integrated raw water transmission system to meet future water needs. The purpose of the transmission system, also known as the Integrated Pipeline (IPL), is to bring water from Lake Palestine, Richland-Chambers Reservoir, and Cedar Creek Reservoir to Dallas and TRWD. The 134-mile long raw water transmission pipeline ranges in diameter from 84-inch to 108-inch and will convey water at a planned peak capacity of 347 MGD. Dallas' portion of the capacity of the shared pipeline is currently planned to be 150 MGD. For the purposes of the 2014 Dallas LRWSP, the IPL strategy has been broken out into two separate, but related projects. The first project for the IPL is delivering water to the Joe Pool area, shared infrastructure with TRWD. The second part of the strategy is delivering water the IPL near the Joe Pool area to the Bachman WTP, likely Dallas only infrastructure.

Water Availability:

Dallas has contracted for 102 MGD of Lake Palestine supply which will be conveyed through the IPL. Assuming an average delivery of the Palestine water results in the IPL will have an unutilized capacity of approximately 48 MGD (or about 53,800 acft/yr) which could be utilized by Dallas to deliver additional water from other strategies located within the Neches River Basin.

Permitting and Environmental Issues:

The Lake Palestine Pipeline project would pose several permitting challenges along with the typical challenges associated with a new project. 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.

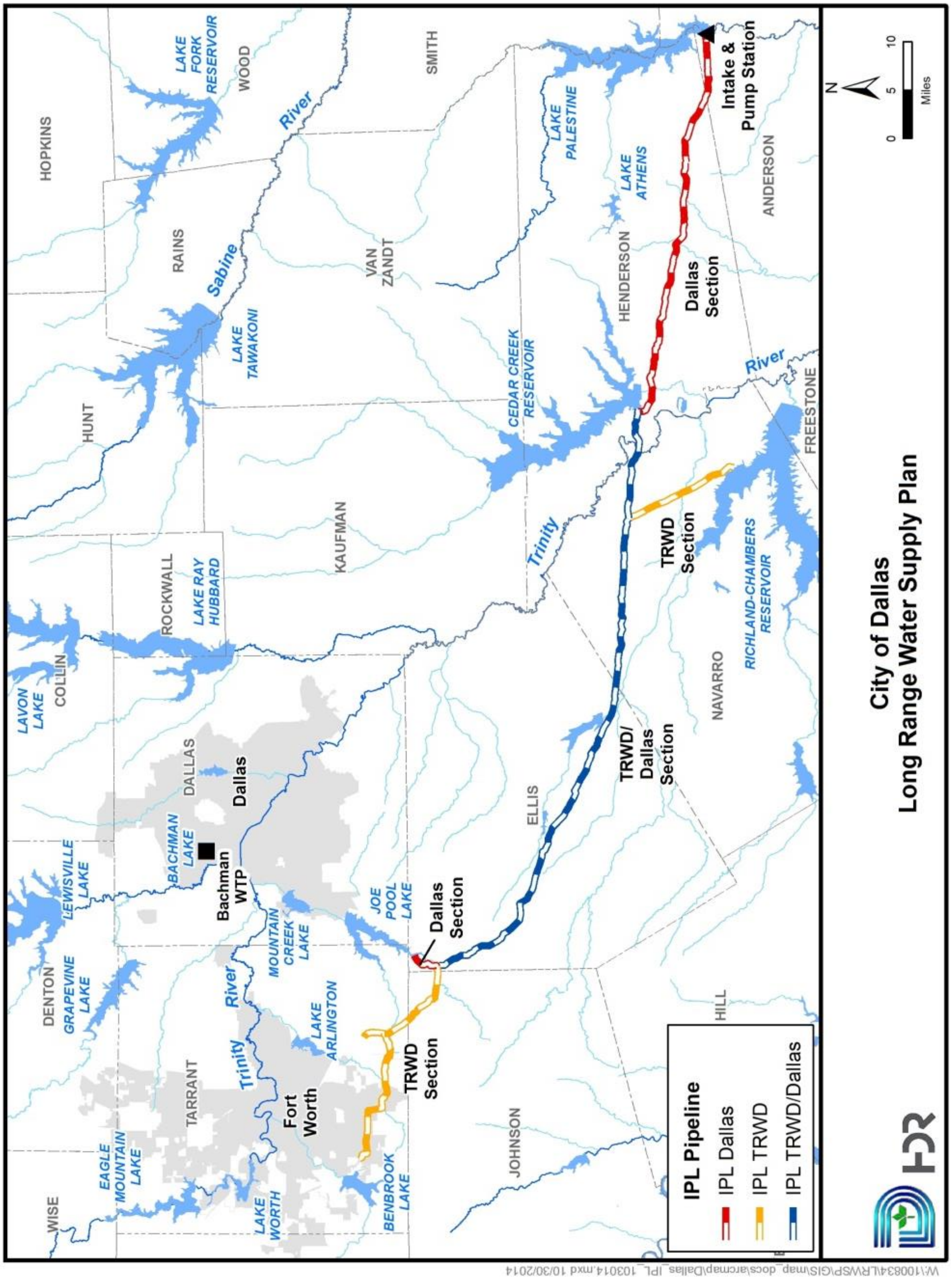
Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$2.31 $0.57	$/1,000 gal	Raw water to the Bachman Turnout
Quantity of Water:	102	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	1,656	acres	

Phasing and Implementation:

Dallas has invested significant capital in the development of this project, and many of the hurdles remaining are centered on land acquisition and construction activities. The following steps are recommendation for implementation of the IPL.

- Re-evaluate the planned 150 MGD capacity of the two Dallas-only segments of the IPL considering the combined supply from the three recommended strategies could supply as much as 194 MGD (Lake Palestine (102 MGD), Neches Run-of-the-River (42 MGD) and Lake Columbia (50 MGD)). Once the delivery capacity is finalized, proceed with the final design of the two Dallas-only pipeline segments of the IPL.
- Determine what metric will initiate the construction of the Dallas segments of the IPL.


City of Dallas
Long Range Water Supply Plan
IPL Pipeline
IPL Dallas
IPL TRWD
IPL TRWD/Dallas
Intake & Pump Station
Dallas Section
TRWD Section
TRWD/ Dallas Section
Dallas Section
TRWD Section
Bachman WTP
Dallas
Fort Worth
N
0 5 10
Miles
HOPKINS
RAINS
HUNT
ROCKWALL
COLLIN
DALLAS
DENTON
TARRANT
WISE
JOHNSON
ELLIS
HILL
NAVARRO
KAUFMAN
VAN ZANDT
HENDERSON
ANDERSON
FREESTONE
SMITH
WOOD
LAKE FORK RESERVOIR
LAKE TAWAKONI
LAKE RAY HUBBARD
LAVON LAKE
LEWISVILLE LAKE
GRAPEVINE LAKE
BACHMAN LAKE
MOUNTAIN CREEK LAKE
JOE POOL LAKE
LAKE ARLINGTON
EAGLE MOUNTAIN LAKE
LAKE WORTH
BENBROOK LAKE
CEDAR CREEK RESERVOIR
RICHLAND-CHAMBERS RESERVOIR
LAKE PALESTINE
LAKE ATHENS
Sabine River
Trinity River
Trinity
River
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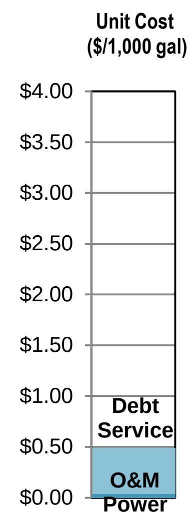
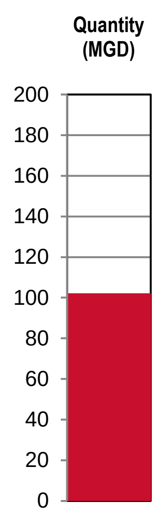
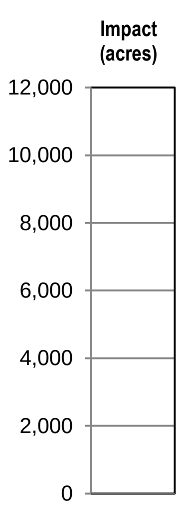
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Integrated Pipeline (IPL) – Part 2 Connection to Bachman WTP**

Status: **Recommended (2027)**

Cost Summary	
Total Project Cost	**$244.3 M**
Annual Debt Service	$16.8 M
Annual O&M and Power	$1.4 M
Total Annual Cost	**$18.2 M**

Description of Strategy:

Several alternative delivery options were evaluated to deliver the IPL water from the Joe Pool Lake area to the Bachman WTP. Of the various options evaluated, the option, which consists of a pipeline to connect the IPL to the Bachman WTP, was chosen as the preferred alternative in the 2014 Dallas LRWSP. The selected route delivers water from the IPL to the Bachman WTP in a closed conduit utilizing gravity and residual head from the IPL with a shallow tunnel to get through a highpoint along the route. This route parallels State Highway 360 along the west side of Joe Pool, then east on Camp Wisdom Road, heads north meandering east of Mountain Creek Lake to ultimately deliver water to the Bachman WTP. At the Bachman WTP the water is discharged above Frasier dam for diversion into Bachman through Fishing Hole Lake. The water relies on the residual head from the IPL and does not require any additional booster pumping stations for this alternative. From the work of the LRWSP it was determined that a west side WTP expansion could be delayed until about 2050, therefore there are no WTP improvement costs included in this estimate. The alternative plan, which provides Dallas some potential cost savings at the expense of potential conflict with other entities, is to discharge the water into Joe Pool and using the streams and reservoirs to transmit the water to the Trinity River, where a channel dam would be placed to back water up to Frasier dam where it could be lifted into the Bachman WTP intake system.

Water Availability:

Dallas has contracted for 102 MGD of Lake Palestine supply which will be conveyed through the IPL. The IPL will have an unutilized capacity of approximately 48 MGD (or about 53,800 acft/yr) which could be utilized by Dallas to deliver additional water from other strategies located within the Neches River Basin. The IPL part 2 is sized to deliver the full 150 MGD capacity, for the purposes of the LRWSP.

Permitting and Environmental Issues:

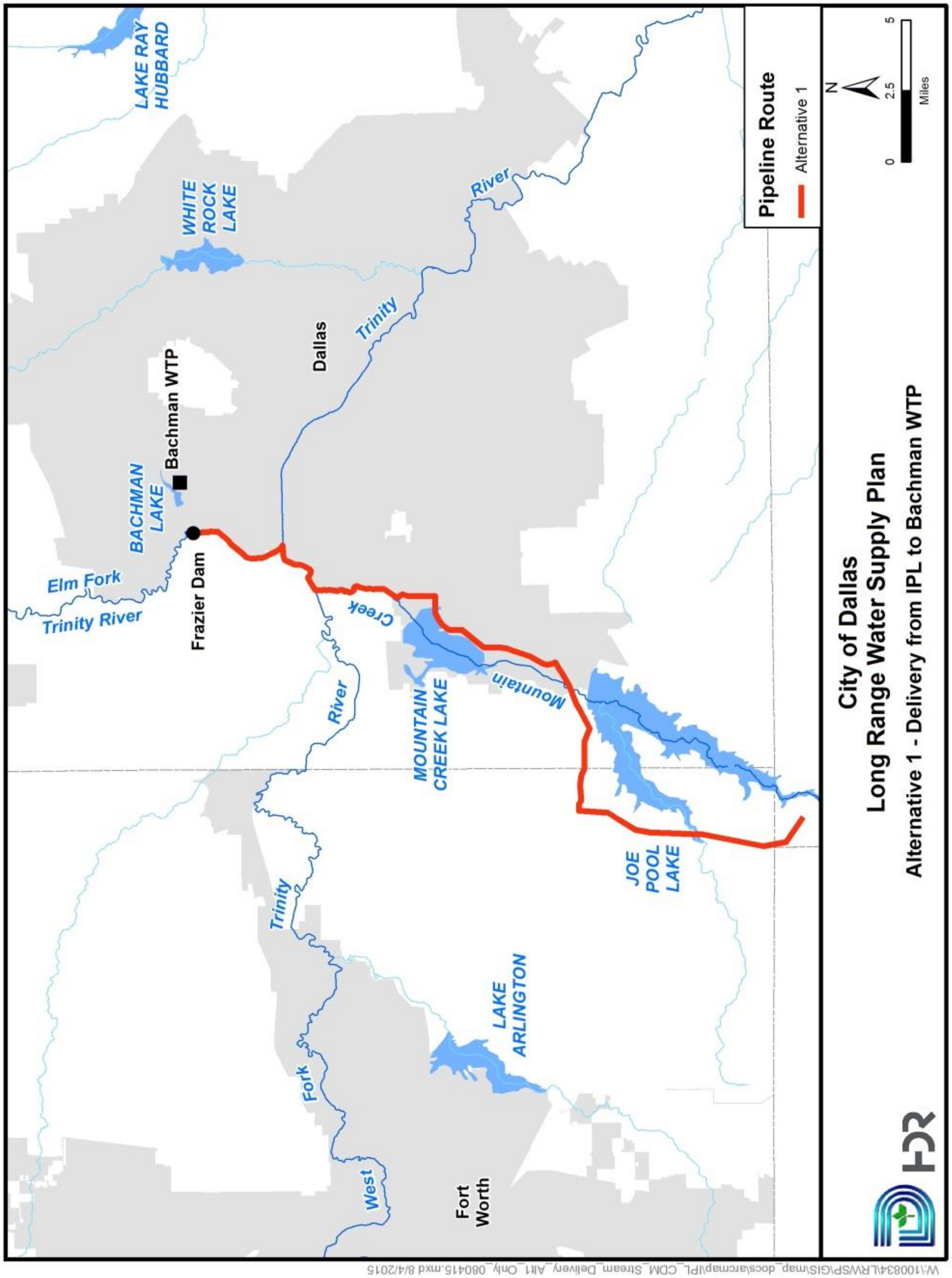
The Bachman WTP connection could pose permitting challenges along with the typical challenges associated with a new project. A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the pipeline. A Section 408 permit, required to cross the levee system, would also be required.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$0.49 $0.04	$/1,000 gal	Raw Water Delivered to Bachman WTP
Quantity of Water:	102	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	552	acres	

Phasing and Implementation:

Dallas should consider a study to evaluate the potential willingness for cooperation with other entities to allow the alternative deliver option using the bed and banks of the stream system. Coordination with the USACE will also be required for any construction activities in the Trinity Levee System.


LAKE RAY HUBBARD
WHITE ROCK LAKE
BACHMAN LAKE
Bachman WTP
Dallas
Trinity
River
Elm Fork
Trinity River
Frazier Dam
Creek
Mountain
MOUNTAIN CREEK LAKE
River
Trinity
JOE POOL LAKE
LAKE ARLINGTON
Fork
West
Fort Worth
Pipeline Route
Alternative 1
N
0
2.5
5
Miles
City of Dallas
Long Range Water Supply Plan
Alternative 1 - Delivery from IPL to Bachman WTP
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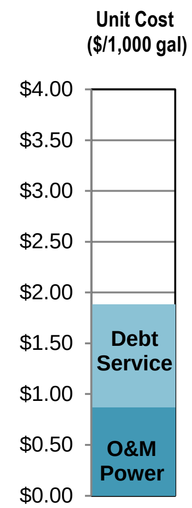
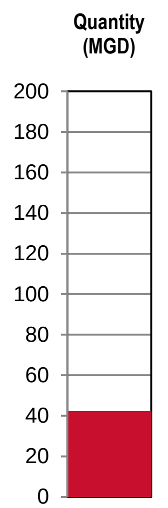
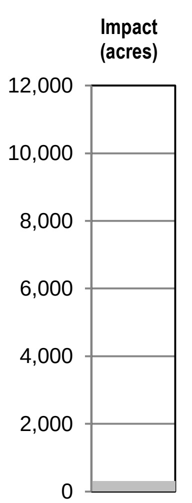
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Upper Neches Project**

Status: **Recommended (2050)**

Cost Summary	
Total Project Cost	**$226.8 M**
Annual Debt Service	$15.6 M
Annual O&M and Power	$13.4 M
Total Annual Cost	**$29.0 M**

Description of Strategy:

In 2013 Dallas and the UNRMWA initiated the Upper Neches River Water Supply Project Feasibility Study to evaluate options to replace the Fastrill Reservoir project that was rendered not feasible. The preferred Upper Neches Project would include run-of-river diversions 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 selected Upper Neches Project 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, 72-inch diameter pipeline 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.

Water Availability:

The Upper Neches Project 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 42.2 MGD (47,250 acft/yr), assuming conjunctive system operations with Lake Palestine.

Permitting and Environmental Issues:

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 waterway from construction activities would be needed for the construction of the diversion facilities and pipeline. Environmental concerns associated with the conjunctive use project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

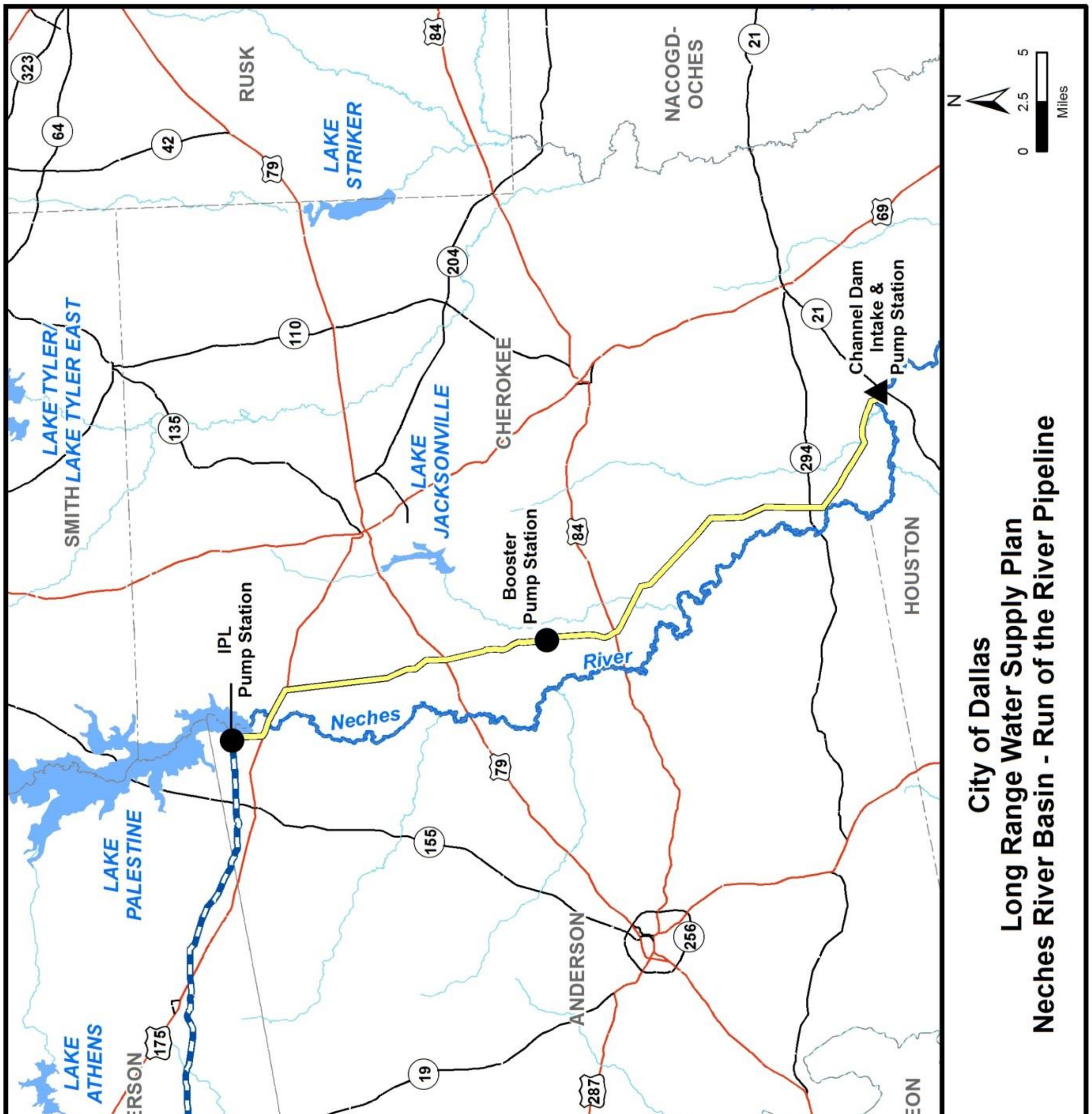
Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$1.88 $0.87	$/1,000 gal	Raw Water Delivered through the IPL to Bachman Turnout
Quantity of Water:	42.2	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	299	acres	

Phasing and Implementation:

The following steps are recommended for implementation of the Upper Neches Project.

- 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 chosen by Dallas as part of the 2014 LRWSP, but would still serve as a recommended strategy for Dallas.
- Develop an agreement with UNRMWA to establish what, if any, local yield of the project may be required to remain in the Neches River Basin.


City of Dallas
Long Range Water Supply Plan
Neches River Basin - Run of the River Pipeline
Legend
Neches Pipeline
IPL Pipeline
IPL
IPL Pump Station
Booster Pump Station
Channel Dam Intake & Pump Station
Neches River
Trinity River
LAKE PALESTINE
LAKE JACKSONVILLE
LAKE STRIKER
LAKE TYLER/ LAKE TYLER EAST
LAKE ATHENS
SMITH
RUSK
CHEROKEE
NACOGD- OCHES
HOUSTON
ANDERSON
HENDERSON
LEON
FREESTONE
0 2.5 5 Miles
N
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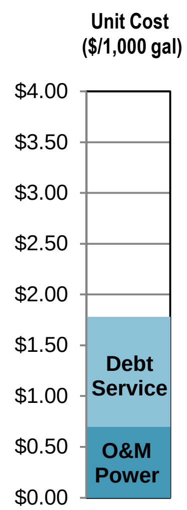
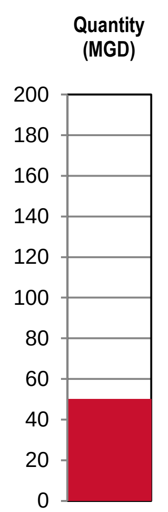
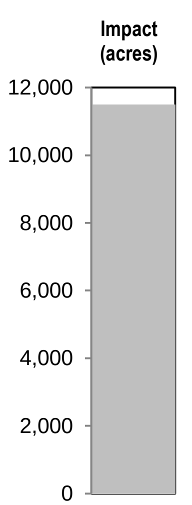
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Lake Columbia**

Status: **Recommended (2070)**

Cost Summary	
Total Project Cost	**$288.6 M**
Annual Debt Service	$19.9 M
Annual O&M and Power	$12.7 M
Total Annual Cost	**$32.6 M**

Description of Strategy:

Lake Columbia is a proposed reservoir project of the ANRA and located on Mud Creek in Cherokee County. The reservoir would be connected to Dallas' western system via a 20 mile, 42-inch diameter pipeline from Lake Columbia to the proposed IPL pump station at Lake Palestine. Water would then be delivered to the Lake Joe Pool area via the IPL. For purposes 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.

Water Availability:

ANRA estimates that after considering local needs, approximately 50 MGD of supply would be available to Dallas. Dallas' capacity in the IPL is 150 MGD and, after considering Dallas' Lake Palestine supply of 102 MGD, the IPL will initially have available excess capacity of about 48 MGD. Considering the potential for Dallas to manage pumping rates from both Lakes Palestine and Columbia, it is reasonable for Dallas to potentially contract for up to 50 MGD of supply from Lake Columbia.

Permitting and Environmental Issues:

ANRA has been granted a water right permit for Lake Columbia by the TCEQ to impound 195,500 acft and to divert 76.3 MGD (85,507 acft/yr). However, the Lake Columbia project is subject to completion of the EIS and issuance of the §404 permit from the USACE, as well as completion of a Source Water Assessment. In addition, TCEQ Permit No. 4228 will have to be amended to allow for interbasin transfers of supplies to the Trinity River Basin.

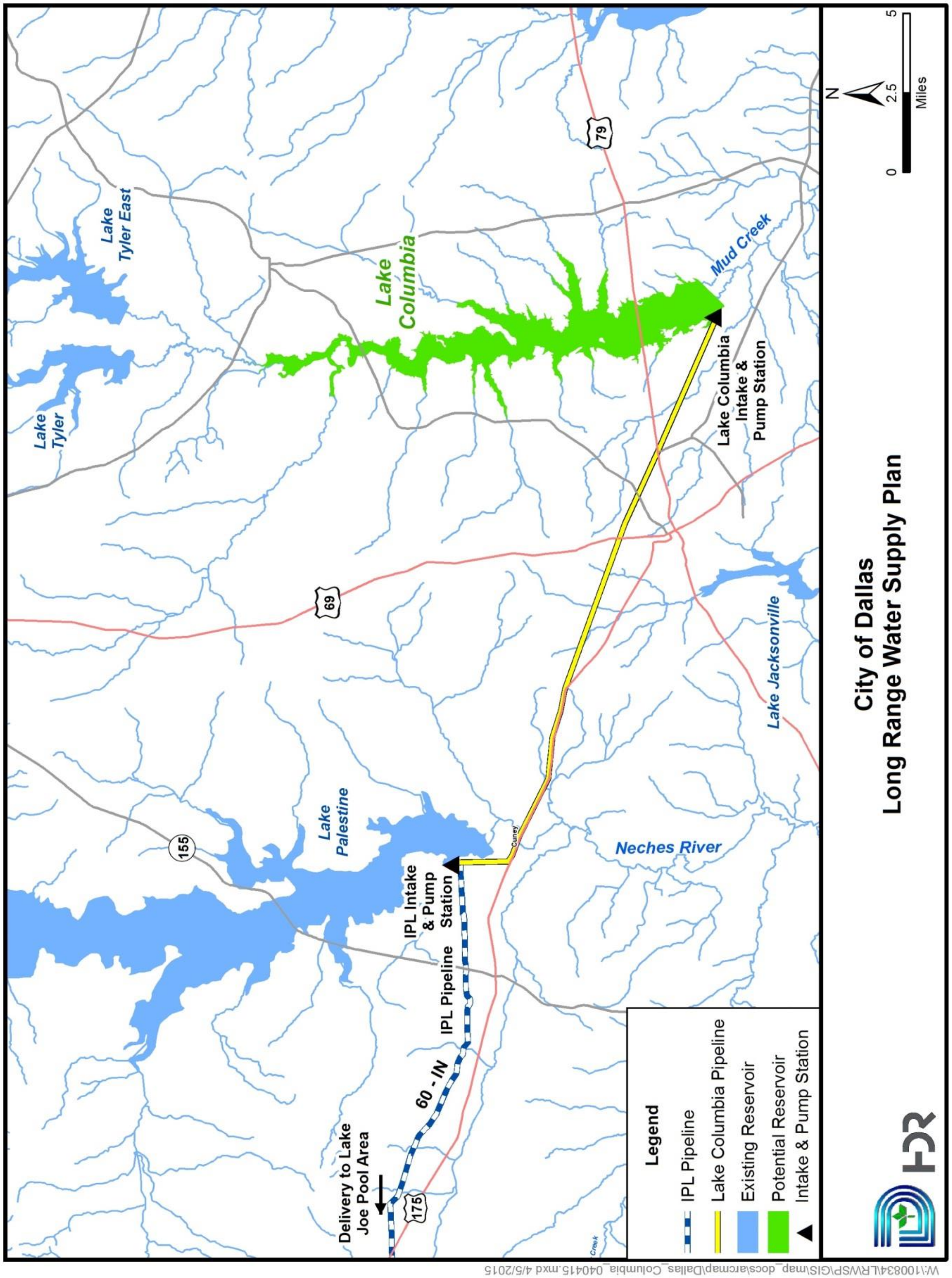
Implementation of the Lake Columbia project will comply with TCEQ Permit No. 4228 which does not currently require instream flow releases and the project could have a significant impact on daily flows on Mud Creek. The large footprint of Lake Columbia would impact approximately 5,751 acres of wetlands and 5,579 acres of bottomland hardwoods and includes a unique habitat area consisting of an herbaceous seepage bog that will require mitigation before for the 404 permit is granted.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$1.78 $0.70	$/1,000 gal	Raw Water Delivered through the IPL to Bachman Turnout
Quantity of Water:	50	MGD	Reliability = Firm; potentially subject to use by local entities
Land Acquired (excluding Mitigation):	8,538	acres	Additional acreage required for mitigation (approx.. 11,000 acres)

Phasing and Implementation:

For implementation, Dallas should continue to partner with the ANRA on the permitting of Lake Columbia including the 404 permitting process and the amendment of ANRA's existing water right to include an interbasin transfer which would authorize Dallas' use of this water in the Trinity River Basin.


Lake Tyler East
Lake Tyler
Lake Columbia
Mud Creek
Lake Columbia Intake & Pump Station
79
69
Lake Jacksonville
Lake Palestine
155
Cuney
Neches River
IPL Intake & Pump Station
IPL Pipeline
60 - IN
Delivery to Lake Joe Pool Area
175
Creek
Legend
IPL Pipeline
Lake Columbia Pipeline
Existing Reservoir
Potential Reservoir
Intake & Pump Station
N
0
2.5
5
Miles
City of Dallas
Long Range Water Supply Plan
HDR
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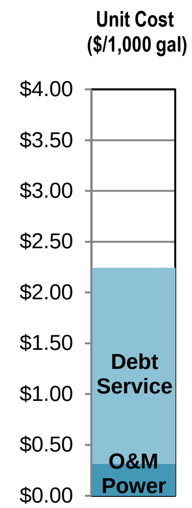
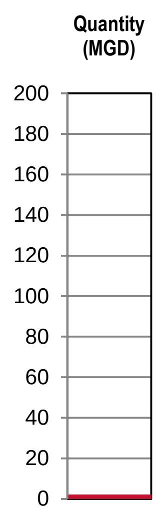
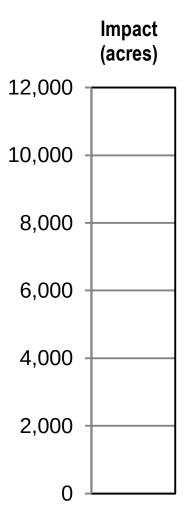
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Direct Non-Potable Reuse**

Status: **Alternative**

Description of Strategy:

Cost Summary	
Total Project Cost	**$27.4 M**
Annual Debt Service	$1.6 M
Annual O&M and Power	$0.2 M
Total Annual Cost	**$1.8 M**

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. 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. 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.

Water Availability:

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 and under Dallas' existing water rights there is sufficient water available from the CWWTP to supply this reuse strategy.

Permitting and Environmental Issues:

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. R10030-001). Additionally, any pipeline crossings associated with waters of the United States will need to be considered in the Section 404 permitting process.

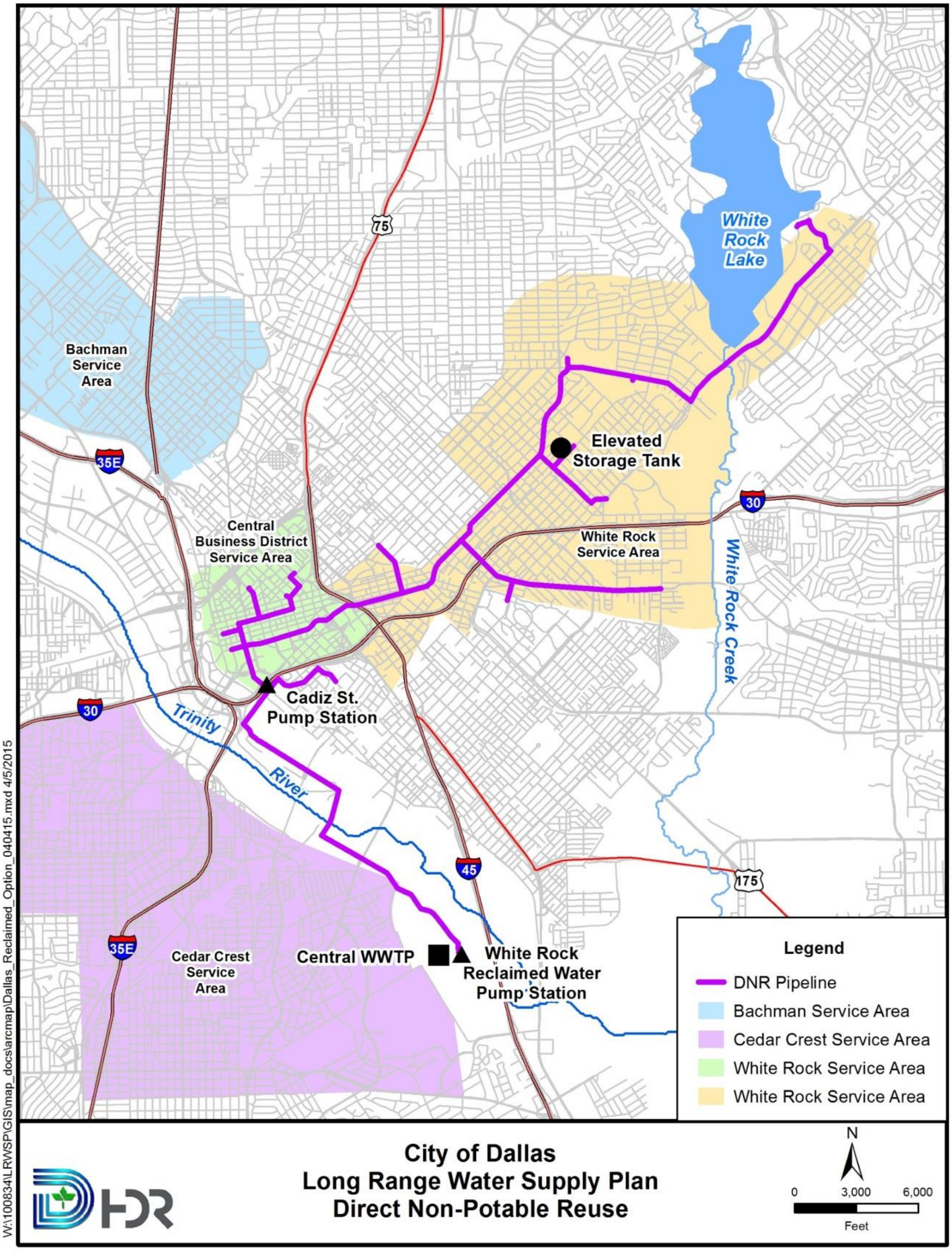
Environmental concerns associated with the conjunctive use project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$2.24 $0.31	$/1,000 gal	Direct Non-Potable Water Delivered
Quantity of Water:	2.23	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):			Utilizes existing Dallas ROW

Phasing and Implementation:

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. It is recommended that Dallas continue to evaluate the potential for direct non-potable reuse customers.


White Rock Lake
Bachman Service Area
Elevated Storage Tank
Central Business District Service Area
White Rock Service Area
White Rock Creek
Cadiz St. Pump Station
Trinity River
Cedar Crest Service Area
Central WWTP
White Rock Reclaimed Water Pump Station
Legend
DNR Pipeline
Bachman Service Area
Cedar Crest Service Area
White Rock Service Area
White Rock Service Area
City of Dallas
Long Range Water Supply Plan
Direct Non-Potable Reuse
N
0
3,000
6,000
Feet
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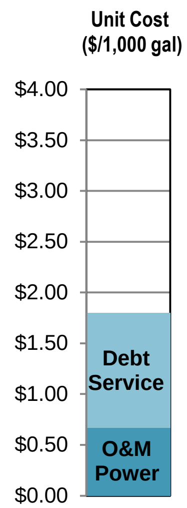
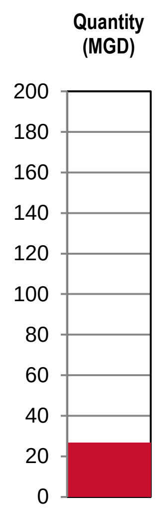
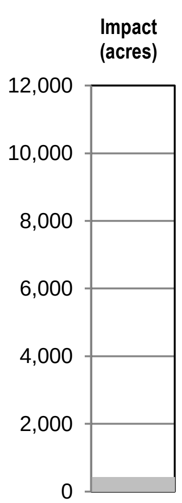
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Carrizo-Wilcox Groundwater Project**

Status: **Alternative**

Description of Strategy:

Cost Summary	
Total Project Cost	**$161 M**
Annual Debt Service	$11.1 M
Annual O&M and Power	$6.5 M
Total Annual Cost	**$17.6 M**

The Carrizo-Wilcox Groundwater strategy 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. Groundwater from the well fields is pumped through a 58 mile transmission system to the existing intake and pump station at Lake Fork. The Lake Fork and Tawakoni transmission pipelines will be used to convey supplies from this strategy to DWU's Eastside WTP.

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. The comparison shows that up to 102,930 acft/yr (92 MGD) of groundwater is potentially available.

A Groundwater Availability Model (GAM) was used to calculate aquifer response to the proposed groundwater project. It was determined that up to 26.8 MGD (30,000 acft/yr) could be developed by DWU in the 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.

Permitting and Environmental Issues:

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 land owners to construct wells and access the groundwater. A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed for the construction of the transmission facilities.

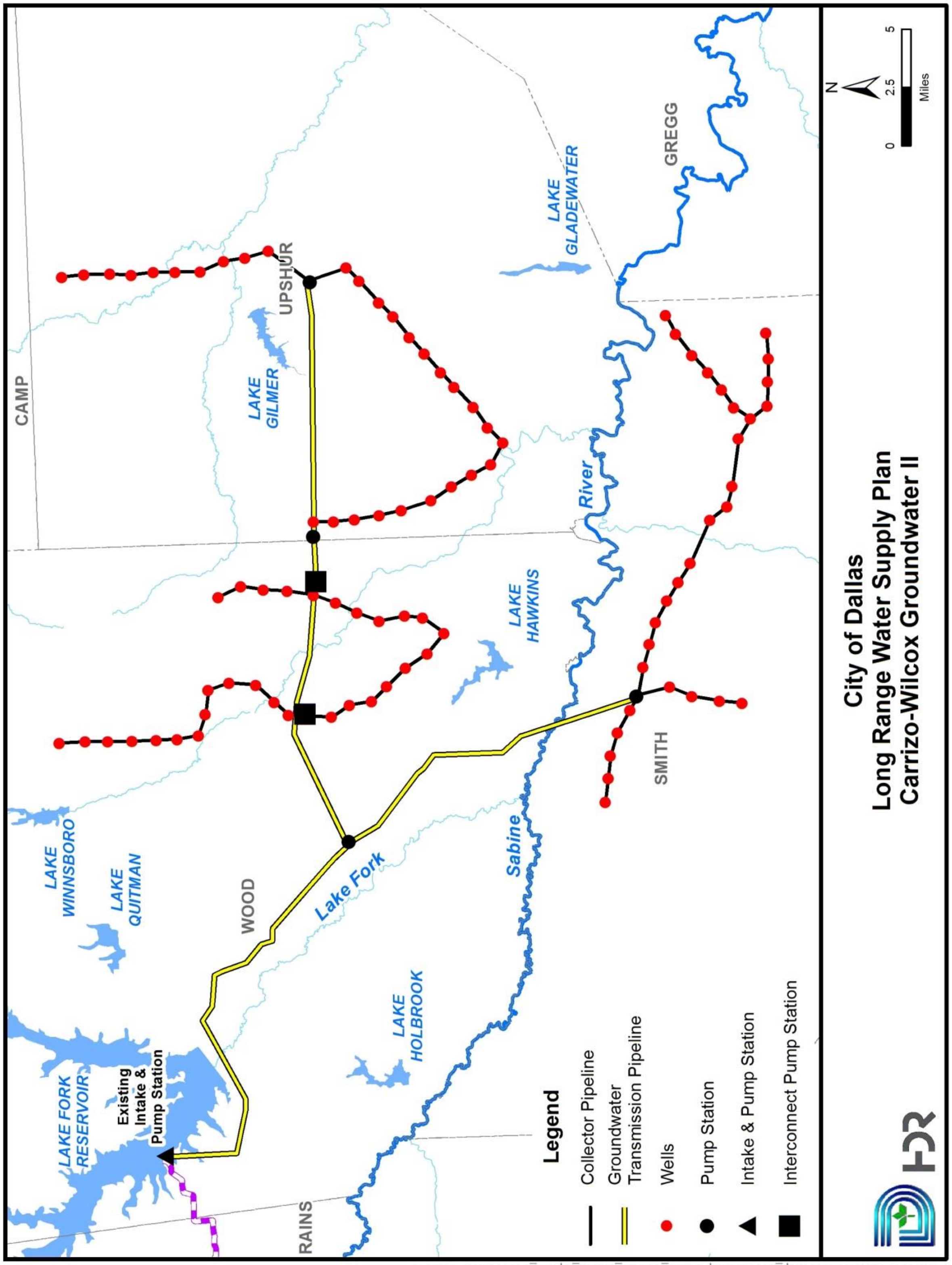
Environmental concerns associated with the conjunctive use project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$1.80 $0.67	$/1,000 gal	Raw Water Delivered to Eastside WTP
Quantity of Water:	26.7	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	435	acres	

Phasing and Implementation:

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. It is recommended that Dallas consider a feasibility study for the use of the Carrizo-Wilcox groundwater.



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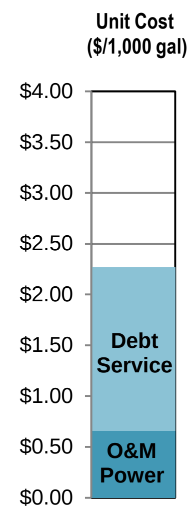
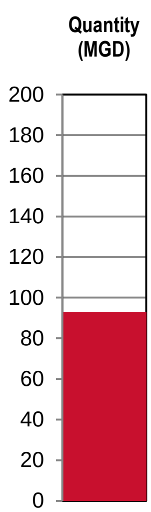
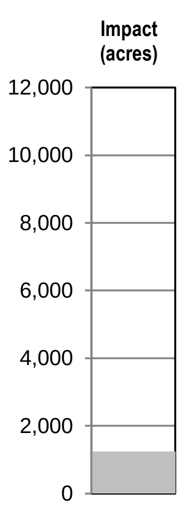
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Sabine Conjunctive Use**

Status: **Alternative**

Description of Strategy:

The Sabine conjunctive use project combines groundwater supplies from the Groundwater project as described in Section 7.9 with an off-channel reservoir (OCR) in Smith County that impounds surface water diverted from the Sabine River. Supplies are delivered to the Lake Fork pump station and then on to the Eastside WTP via the Eastside Pipeline.

Cost Summary	
Total Project Cost	**$795.8 M**
Annual Debt Service	$54.8 M
Annual O&M and Power	$22.3 M
Total Annual Cost	**$77.1 M**

Water Availability:

The combination of the two projects has the potential to provide a larger volume of water to Dallas. The system 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 conjunctive use system is able to provide a firm yield of 93 MGD (104,200 acft/yr). 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.

Permitting and Environmental Issues:

Implementation of the Sabine River diversion and OCR will require permits from both state and federal agencies. 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. Currently, there are no local groundwater conservation districts in the well field locations and consequently no pumping permits would be required for the groundwater.

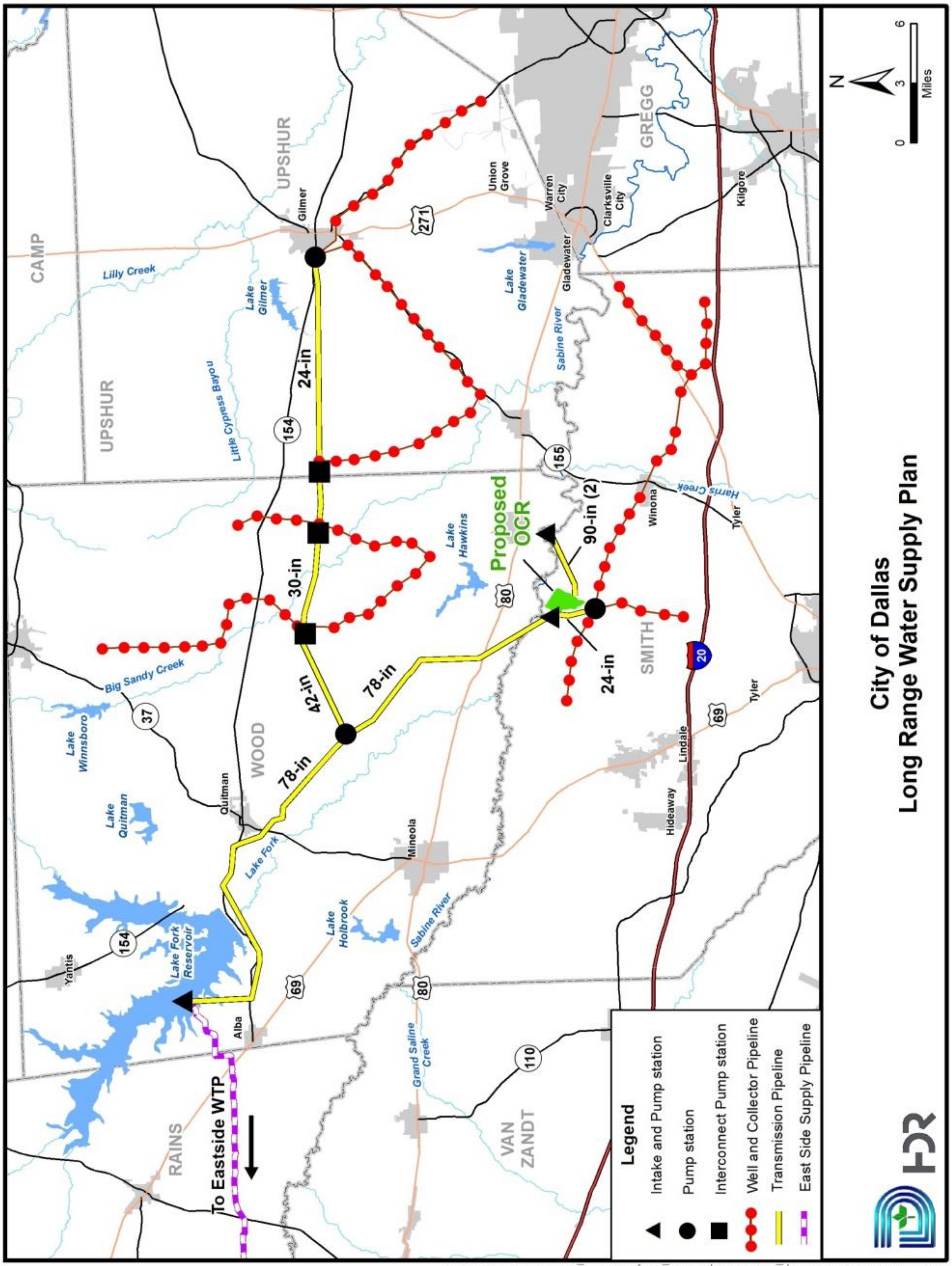
Environmental concerns associated with the conjunctive use project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be low.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$2.27 $0.66	$/1,000 gal	Raw Water Delivered to Eastside WTP
Quantity of Water:	93.0	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	1,239	acres	

Phasing and Implementation:

To pump groundwater, DWU would need to either purchase the land for the wells or enter into lease agreements with land owners to construct wells and access the groundwater. It is recommended that Dallas consider a feasibility study with other regional partners for the conjunctive use of Carrizo Wilcox groundwater and diversions of Sabine River water to an OCR.


City of Dallas
Long Range Water Supply Plan
Legend
Intake and Pump station
Pump station
Interconnect Pump station
Well and Collector Pipeline
Transmission Pipeline
East Side Supply Pipeline
N
0
3
6
Miles
To Eastside WTP
Proposed OCR
90-in (2)
78-in
78-in
42-in
30-in
24-in
24-in
CAMP
UPSHUR
UPSHUR
WOOD
GREGG
SMITH
RAINS
VAN ZANDT
Lake Fork Reservoir
Lake Winnsboro
Lake Quitman
Lake Holbrook
Lake Hawkins
Lake Gilmer
Lake Gladewater
Sabine River
Big Sandy Creek
Lilly Creek
Little Cypress Bayou
Lake Fork
Grand Saline Creek
Harris Creek
Gilmer
Union Grove
Warren City
Clarksville City
Gladewater
Kilgore
Winona
Tyler
Lindale
Hideaway
Mineola
Quitman
Yantis
Alba
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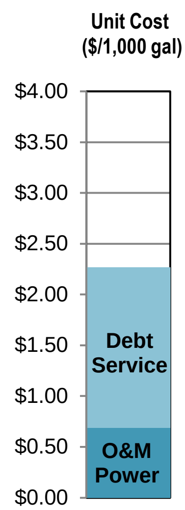
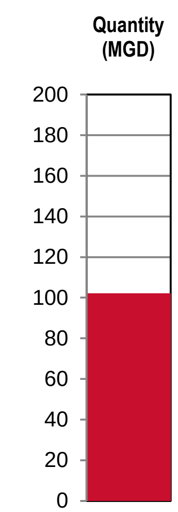
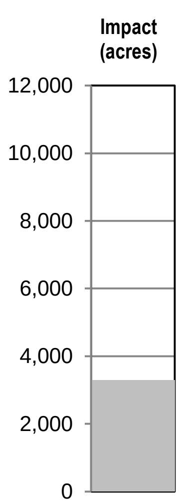
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Red River Off-Channel Reservoir**

Status: **Alternative**

Description of Strategy:

Cost Summary	
Total Project Cost	**$853.0 M**
Annual Debt Service	$58.7 M
Annual O&M and Power	$25.5 M
Total Annual Cost	**$84.2 M**

The Red River Off-Channel Reservoir (OCR) project has the potential to generate a significant amount of supply for Dallas and potentially other regional partners. The Red River OCR project includes a 162 MGD (250 cfs) intake and pump station on the Red River at Arthur City, TX immediately downstream of the Highway 271 bridge. Diversions from the Red River would be pumped approximately 2 miles via an 84-in pipeline to three OCRs in series for sediment removal, water quality improvement and storage. Water would then be diverted from the storage OCR by a 129 MGD (200 cfs) intake and pump station and would transport, on average, about 102 MGD (114,000 acft/yr) via a 100 mile, 84-in transmission pipeline to Lake Ray Roberts for subsequent blending and use by Dallas.

Water Availability:

This OCR storage basin will have an active conservation pool capacity of 32,000 acft which was determined 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. Additional yield estimates were performed using higher diversion rates and indicate that an expansion of the facilities would be able to provide upwards of 535 MGD (600,000 acft/yr) of regional supply with a high level of reliability.

Permitting and Environmental Issues:

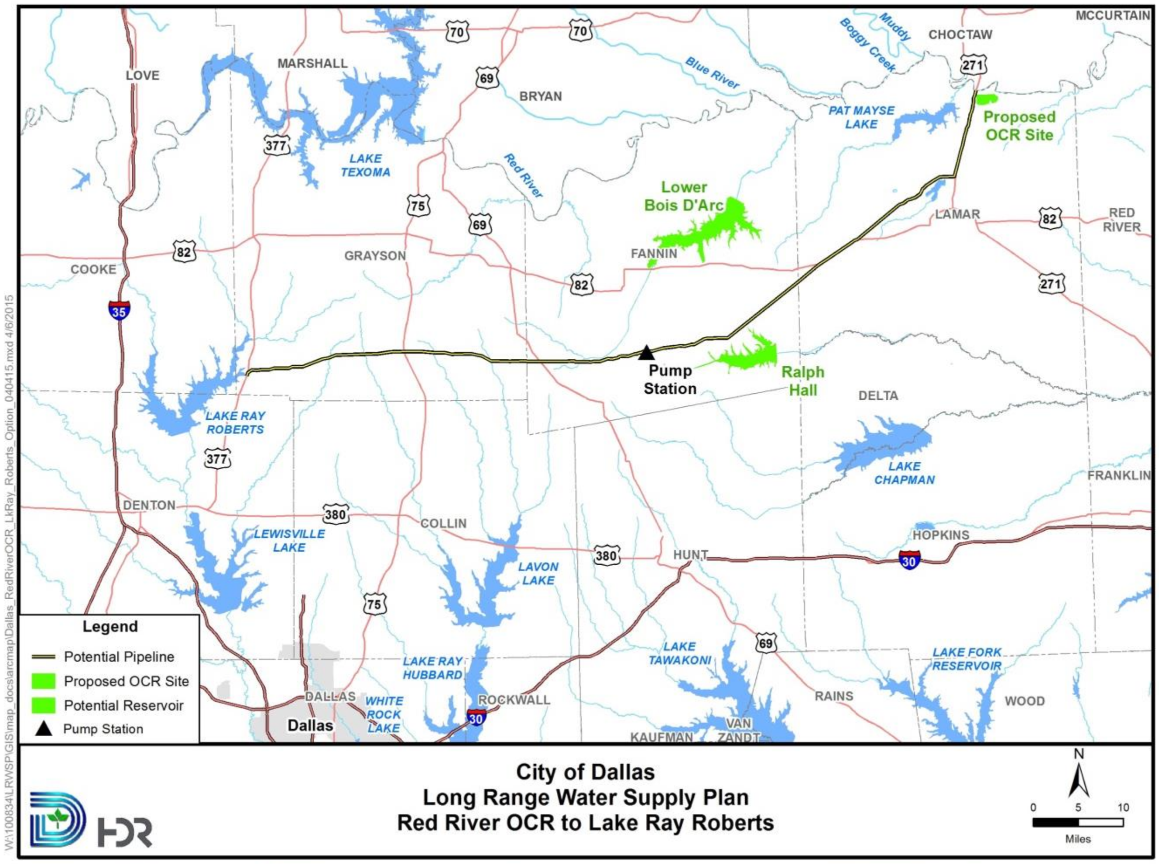
Implementation of the Red River OCR will require permits from both state and federal agencies. A Section 404 permit from the USACE for impacts to a waterway from construction activities would be needed. Diversions from the Red River would need to comply with the Red River Compact and potentially with provisions of the Lacey Act which prohibits the transport of non-native species across state boundaries, and in this case, zebra mussels. Environmental concerns associated with the conjunctive use project including impacts to habitat, threatened and endangered species, wetlands, and freshwater inflows are all anticipated to be a low.

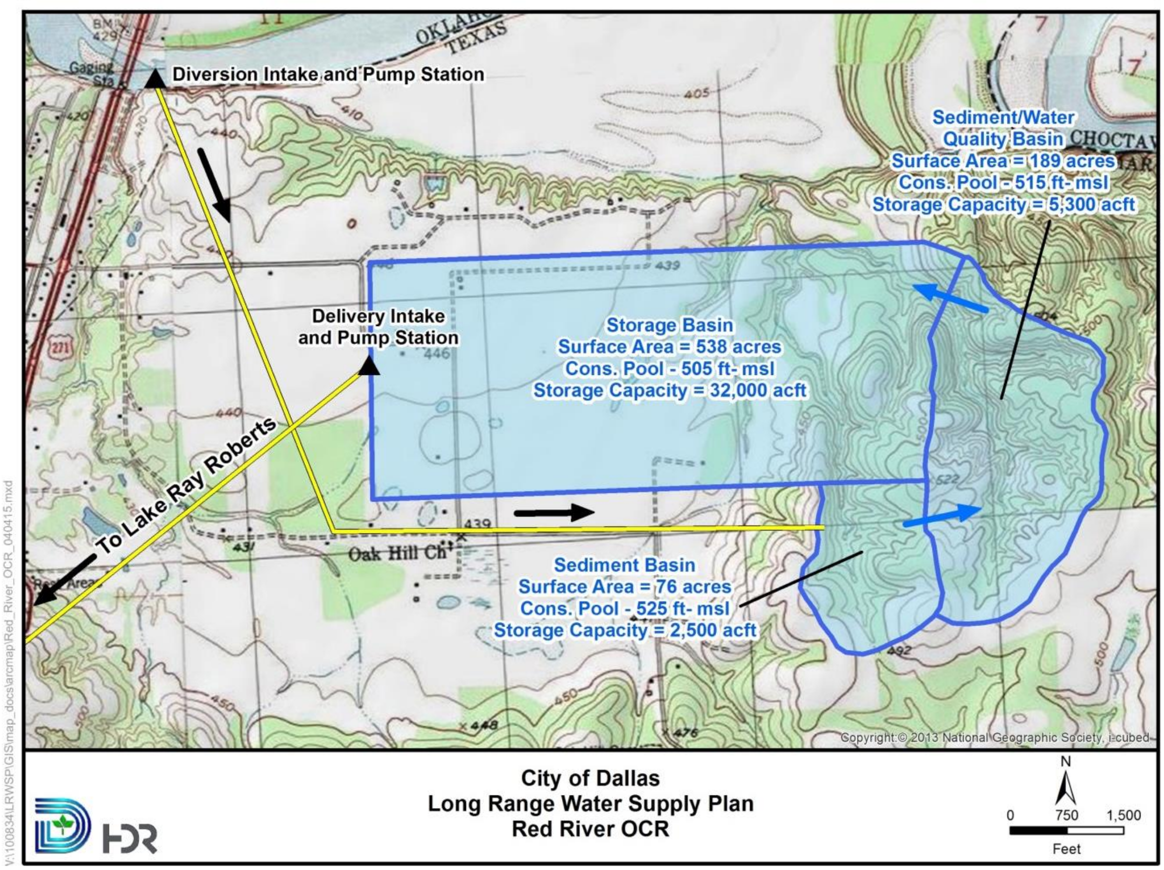
Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$2.27 $0.69	$/1,000 gal	Raw Water Delivered to Ray Roberts
Quantity of Water:	102	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	3,286	acres	

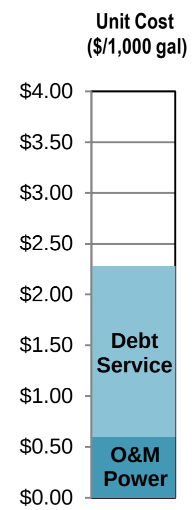
Phasing and Implementation:

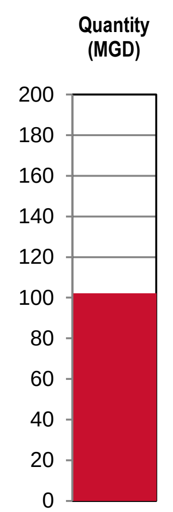
The Red River OCR has the potential to be phased for expansion to provide supplies to multiple regional partners. Implementation concerns include the additional regulatory and permitting challenges associated with the Red River compact and Lacey Act and bank stability for the intake structure. It is recommended that Dallas initiate a feasibility study of the Red River OCR option, as a regional study with other partners, to evaluate the potential for that strategy to develop reliable supply. This study would include analyses on water availability, Red River Compact issues, water quality and invasive species concerns, regional delivery options, and constructability of an intake on the Red River.

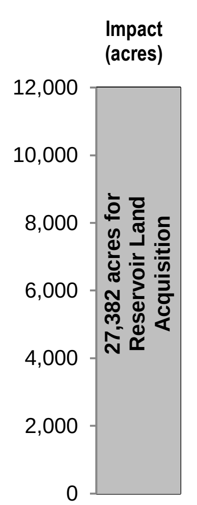

City of Dallas
Long Range Water Supply Plan
Red River OCR to Lake Ray Roberts
Legend
Potential Pipeline
Proposed OCR Site
Potential Reservoir
Pump Station
Proposed OCR Site
Lower Bois D'Arc
Pump Station
Ralph Hall
LAKE RAY ROBERTS
LAKE TEXOMA
PAT MAYSE LAKE
LAKE CHAPMAN
LEWISVILLE LAKE
LAVON LAKE
LAKE RAY HUBBARD
WHITE ROCK LAKE
LAKE TAWAKONI
LAKE FORK RESERVOIR
Dallas
Miles


City of Dallas
Long Range Water Supply Plan
Red River OCR
Diversion Intake and Pump Station
Delivery Intake and Pump Station
To Lake Ray Roberts
Storage Basin
Surface Area = 538 acres
Cons. Pool - 505 ft- msl
Storage Capacity = 32,000 acft
Sediment/Water Quality Basin
Surface Area = 189 acres
Cons. Pool - 515 ft- msl
Storage Capacity = 5,300 acft
Sediment Basin
Surface Area = 76 acres
Cons. Pool - 525 ft- msl
Storage Capacity = 2,500 acft
Copyright:© 2013 National Geographic Society, i-cubed
Feet

RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Sulphur Basin River Project**

Status: **Alternative**

Description of Strategy:

Cost Summary (Dallas Portion)	
Total Project Cost	**$1,003.1 M**
Annual Debt Service	$62.5 M
Annual O&M and Power	$22.1 M
Total Annual Cost	**$84.6 M**

As currently operated, Wright Patman Lake provides over 2.5 million acre-feet of storage for floodwaters. Significant additional water supply yield could be generated if the flood storage in Wright Patman Lake were reallocated to municipal use. The City of Texarkana has contracted with the USACE for storage in the lake and holds a Texas water right to use up to 160.6 MGD (180,000 acft/yr) from the lake.

The Marvin Nichols IA site is a recommended strategy for NTMWD, the UTRWD, and TRWD in the 2006 and 2011 Region C Regional Water Plan and an alternative strategy for Dallas and the City of Irving in the 2011 plan. The reservoir would have a storage capacity of 1,532,031 acre-feet. Supplies for Dallas from the two reservoirs would be pumped through the main transmission pipeline and delivered to the Elm Fork of the Trinity River downstream of Lake Ray Roberts.

Water Availability:

Based on the July 2014 SRBA report, combined yield associated with reallocating Wright Patman to 232.5 ft and construction of Marvin Nichols to 296.5 ft produces a project yield of 485 MGD (543,197 acft/yr). Dallas' portion of the project supply is assumed to be 102 MGD (114,000 acft/yr)

Permitting and Environmental Issues:

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 need to obtain a 404 permit from the USACE for impacts to a waterway from construction activities.

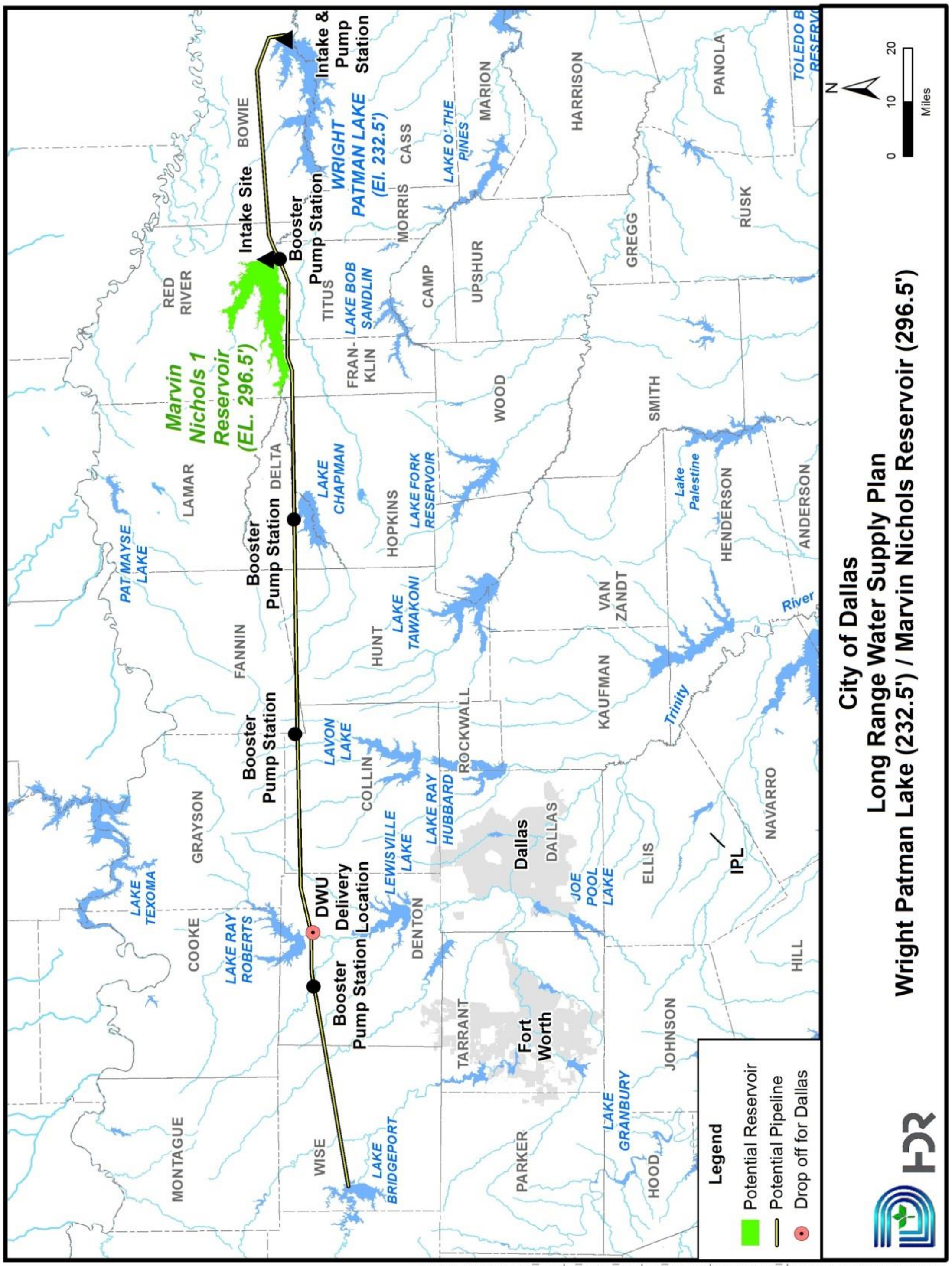
The footprints of both the Wright Patman and Marvin Nichols projects contain heavily forested and agricultural areas including crops and pasture. Impacts to preferred habitats within the reservoir areas will be minimized to some extent by utilizing the agricultural areas which have been previously disturbed.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$2.28 $0.60	$/1,000 gal	Raw Water Delivered to Lake Lewisville
Quantity of Water:	102	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	27,382	acres	Required for Reservoir

Phasing and Implementation:

This project has a high possibility of phasing because of the multiple water supply sources and multiple partners that would be involved in the project. Pending the final JCPD Sulphur Basin Report, it is recommended that Dallas continue to participate in the Sulphur Basin Project with other regional partners.



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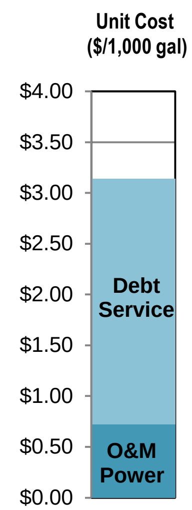
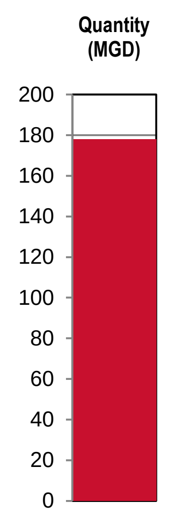
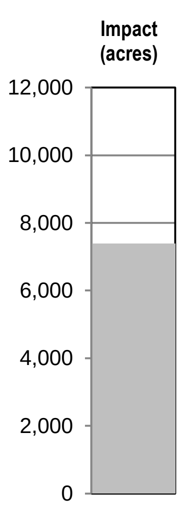
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Toledo Bend to West System**

Status: **Alternative**

Description of Strategy:

Cost Summary (Dallas Portion)	
Total Project Cost	**$2,290.1 M**
Annual Debt Service	$157.6 M
Annual O&M and Power	$47.1 M
Total Annual Cost	**$204.7 M**

DWU, TRWD, NTMWD, and SRA Texas have been collaborating for many years on a potential transfer of water form Toledo Bend Reservoir to the upper Sabine River basin and to the Dallas-Fort Worth (DFW) Metroplex. A shared 225 mile pipeline would be needed to deliver supplies between the reservoir and DWU with deliveries to DWU being assumed to be to the Joe Pool Lake area and other lakes along the route.

Water Availability:

Though the details of the potential transfer have changed over time, it is assumed for purposes of this analysis that a total of 625 MGD (700,000 acft/yr) could be purchased with 179 MGD (200,000 acft/yr) going to Dallas.

Permitting and Environmental Issues:

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 inter-basin transfer authorization to allow the water to be used in the Trinity River Basin. A Section 404 permit from the USACE for impacts to a waterway will be needed for construction of the diversion facilities and pipeline.

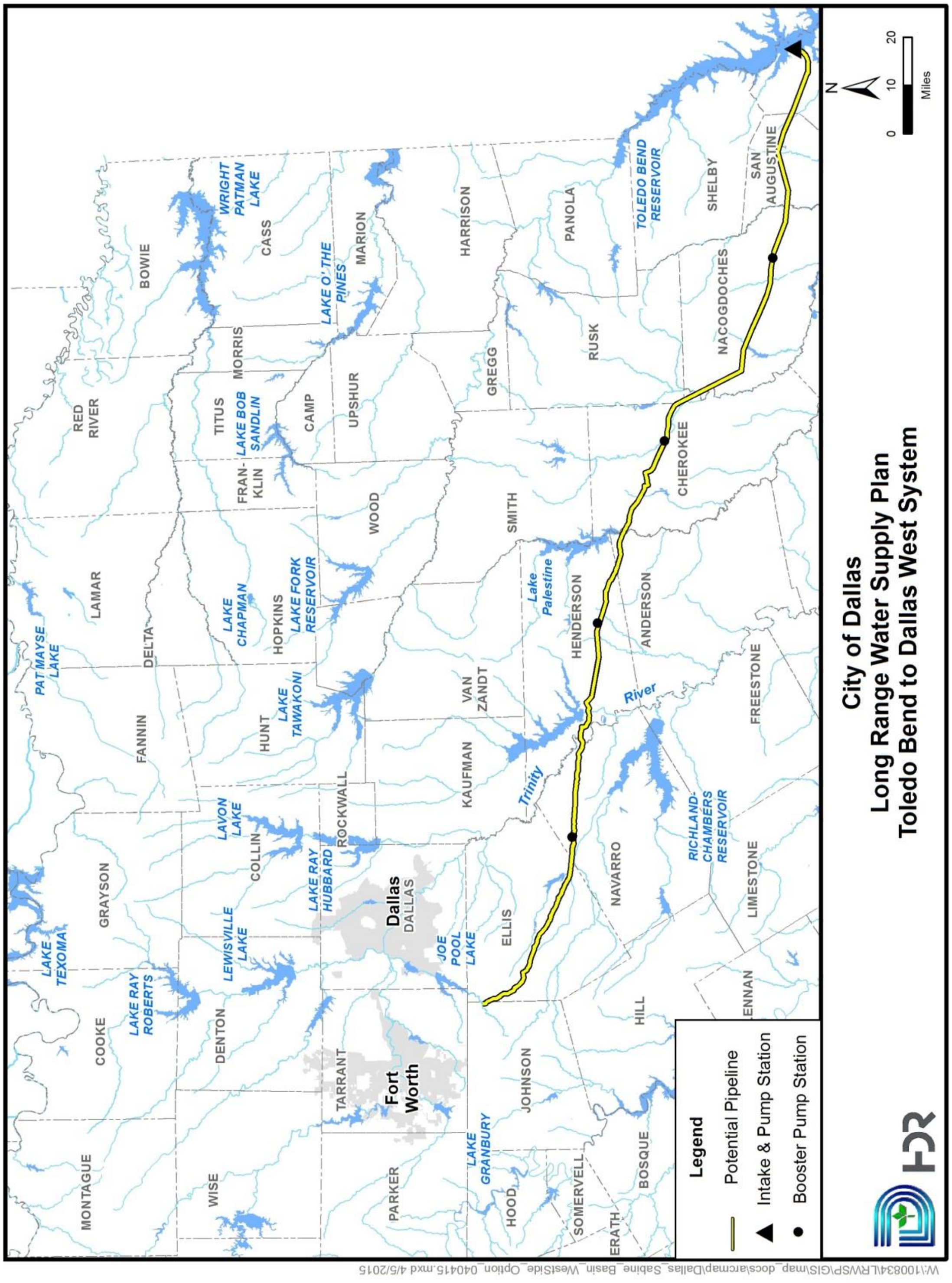
Since the reservoir is an existing source of water, impacts to the environment are limited to the pipeline route, environmental flows downstream of Toledo Bend and transmission facilities to the various water bodies. Implementation and operation of this strategy could have a medium impact on daily flows in the Sabine River due to the amount of supply diverted from storage that might have been previously passed downstream. Transporting of supplies out of the basin will impact flows to Sabine Lake and its estuary downstream of Toledo Bend Reservoir. Freshwater stream flows are critical to the health of the Sabine estuary system. Quantifying that impact will require additional detailed analysis.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$3.14 $0.72	$/1,000 gal	Raw Water Delivered to Joe Pool Area
Quantity of Water:	179	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	7,385	acres	

Phasing and Implementation:

The Toledo Bend project is susceptible to permitting risk and competition. Supply volumes are not fixed until a contract is signed and current negotiations between SRA Texas and other entities in Southeastern Texas could reduce DWU, NTMWD, TRWD proposed portion of supply, unless SRA Texas can secure additional water. SRA Texas is seeking the right to divert an additional 262 MGD (293,300 acft/yr) from TCEQ. Without sufficient supply, the project could become cost prohibitive. It is recommended that Dallas continue to participate in planning efforts for the Toledo Bend project with other regional partners.


City of Dallas
Long Range Water Supply Plan
Toledo Bend to Dallas West System
Legend
Potential Pipeline
Intake & Pump Station
Booster Pump Station
N
0 10 20
Miles
MONTAGUE
COOKE
GRAYSON
LAKE TEXOMA
LAKE RAY ROBERTS
WISE
DENTON
LEWISVILLE LAKE
COLLIN
LAVON LAKE
LAKE RAY HUBBARD
ROCKWALL
PARKER
TARRANT
Fort Worth
Dallas
DALLAS
JOE POOL LAKE
LAKE GRANBURY
HOOD
JOHNSON
ELLIS
SOMERVELL
ERATH
BOSQUE
HILL
NAVARRO
KAUFMAN
Trinity
River
VAN ZANDT
HUNT
LAKE TAWAKONI
FANNIN
PAT MAYSE LAKE
LAMAR
DELTA
HOPKINS
LAKE CHAPMAN
LAKE FORK RESERVOIR
RED RIVER
FRAN-KLIN
TITUS
LAKE BOB SANDLIN
MORRIS
CAMP
UPSHUR
WOOD
BOWIE
CASS
WRIGHT PATMAN LAKE
MARION
LAKE O' THE PINES
HARRISON
GREGG
SMITH
Lake Palestine
HENDERSON
ANDERSON
FREESTONE
RICHLAND-CHAMBERS RESERVOIR
LIMESTONE
CHEROKEE
RUSK
PANOLA
NACOGDOCHES
SHELBY
TOLEDO BEND RESERVOIR
SAN AUGUSTINE
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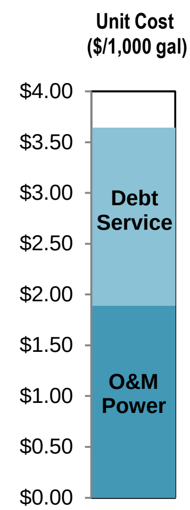
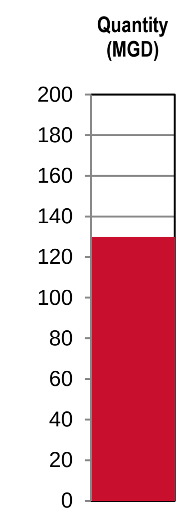
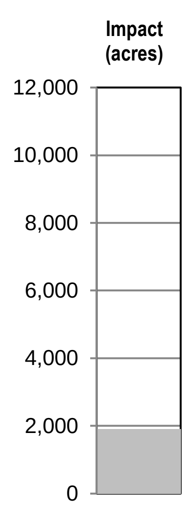
RECOMMENDED AND ALTERNATIVE WATER MANAGEMENT STRATEGIES







Project Name: **Lake Texoma Pipeline and Advanced WTP**

Status: **Alternative**

Description of Strategy:

Supplies from Lake Texoma 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 and then pump the treated water to the clear wells at DWU's Elm Fork WTP.

Cost Summary	
Total Project Cost	**$1,382.1 M**
Annual Debt Service	$94.8 M
Annual O&M and Power	$73.6 M
Total Annual Cost	**$168.4 M**

Water Availability:

Although the potential water supply capability of Lake Texana is very large, none of its unutilized yield is currently available to Texas entities. Potentially, up to 162,271 acft/yr (145 MGD) of Oklahoma's share of Lake Texoma could be made available if Oklahoma entities were willing to sell all or a portion of its allocation to Texas. This would require a contract or permit between Oklahoma entities and DWU. Additionally, an additional supply of 220,000 acft/yr (196 mgd) could potentially be made available to Texas entities if the U.S. Congress would authorize the reallocation of hydropower storage in to municipal water supply.

Permitting and Environmental Issues:

Dallas would require a contract with some entity in Oklahoma that has permitted rights to Oklahoma's share of the yield through the 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.

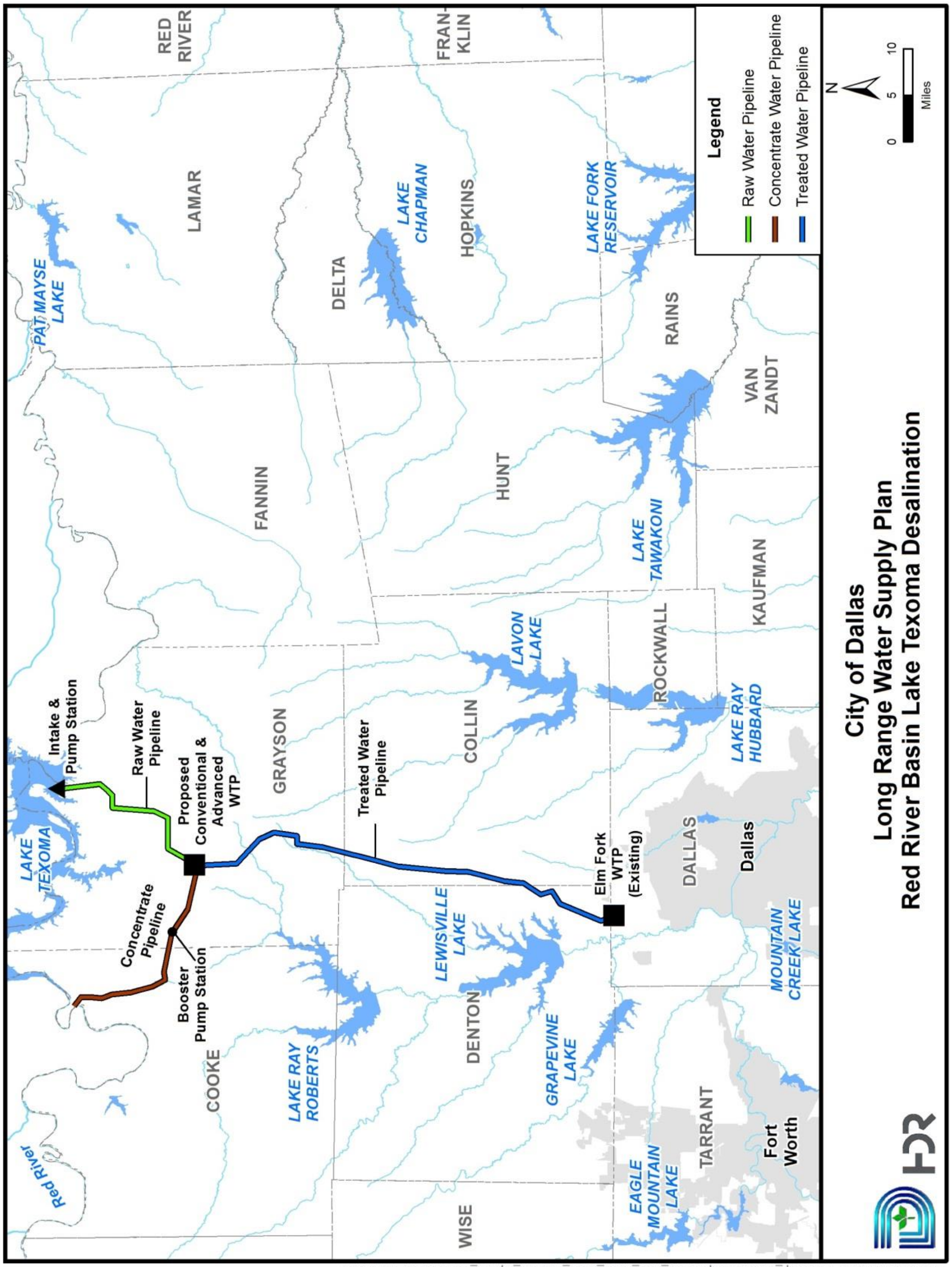
Since the reservoir is an existing source of water, impacts to the environment are limited to the pipeline route, changes in the levels of dissolved minerals in the river from return of the desalination concentrate, and environmental flows downstream of Lake Texoma. Implementation and operation of the 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.

Costs:

Unit Cost, Quantity of Water, and Land Impacted			
Unit Cost of Water: O&M Unit Cost:	$3.64 $1.89	$/1,000 gal	Treated Water Delivered to Elm Fork WTP Clearwell
Quantity of Water:	130	MGD	Reliability = Firm
Land Acquired (excluding Mitigation):	1,905	acres	

Phasing and Implementation:

It is recommended that Dallas consider beginning negotiations with Oklahoma and/or the USACE for access to additional water in Lake Texoma to supply the potential desalination project.


City of Dallas
Long Range Water Supply Plan
Red River Basin Lake Texoma Desalination
Legend
Raw Water Pipeline
Concentrate Water Pipeline
Treated Water Pipeline
N
0 5 10
Miles
Intake & Pump Station
Raw Water Pipeline
Proposed Conventional & Advanced WTP
Treated Water Pipeline
Elm Fork WTP (Existing)
Concentrate Pipeline
Booster Pump Station
Red River
LAKE TEXOMA
PAT MAYSE LAKE
LAKE CHAPMAN
LAKE FORK RESERVOIR
LAKE TAWAKONI
LAVON LAKE
LAKE RAY HUBBARD
LEWISVILLE LAKE
LAKE RAY ROBERTS
GRAPEVINE LAKE
MOUNTAIN CREEK LAKE
EAGLE MOUNTAIN LAKE
RED RIVER
LAMAR
FRAN-KLIN
DELTA
HOPKINS
FANNIN
HUNT
RAINS
VAN ZANDT
GRAYSON
COLLIN
ROCKWALL
KAUFMAN
DALLAS
Dallas
COOKE
DENTON
WISE
TARRANT
Fort Worth
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Appendix L

Previously and Newly Defined Strategies Identified and Evaluated as Part of the 2014 Dallas LRWSP

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Appendix L: Identified and Evaluated Water Management Strategies

Legend
R = Recommended for Construction in Report
S = Identified and Studied New in the 2014 LRWSP
A = Alternative Evaluated but NOT Recommended

Water Management Strategy for DWU from 2011 Region C and 2012 State Water Plans	Primary Responsibility	Projected Supply (ac-ft/yr)	Latest Capital Cost ($ Millions)	Unit Cost ($/ac-ft/yr)	Date of Cost Est.	1990 SWP (50yr)	1992 SWP	2000 LRWSP	2002 SWP	2005 LRWSP	2007 SWP	2007 Model	2008 Reservoir	2008 Tawakoni	2008 Tawakoni Recycle	2008 NTMWD & DWU	2009 4 County	2010 5-Yr Strategic Plan	2010 Dallas Delivery	2011 Region C	2012 Ellis & Johnson Study	2012 SWP	2014 LRWSP	
Conservation and Reuse																								
Cedar Crest Direct Recycle		1,962	$6.5	238	2010			R		R								R						
Conservation (Retail)	CDM	52,987	na	na	2005					R								R		R		R		
Conservation (Wholesale)	CDM	44,677	na	na	2005					R								R		R		R		
DWU Reuse- Direct - HDR - Dallas	HDR	50,382	$82.9	233	2012						A									R		R		
DWU Reuse (Additional)		20,458	$82.9		2011															R				
Indirect Recycle to Lewisville Lake		67,260	$185.7	196	2010					R								R						
TRA 10-Mile Creek Reuse Project		6,760	$14.9	259	2012						R									R		R		
Lake Tawakoni Recycled Water - Option 1A (25mgd PS @SSWWTP & 42" to Trinity Basin Wetland)		28,025	$74.2		2008										A									
Lake Tawakoni Recycled Water - Option 1B (55mgd PS @SSWWTP & 60" to Trinity Basin Wetland)		61,655	$132.2		2008										A									
Lake Tawakoni Recycled Water - Option 1C (125mgd PS @SSWWTP, 60" & 66" to Trinity Basin Wetland)		140,125	$140.5		2008										A									
Lake Tawakoni Recycled Water - Option 1D (125mgd @SSWWTP, 55mgd to Trinity Basin Wetland & 70mgd to Sabine Basin Wetland)		140,125	$143.0		2008										A									
Lake Tawakoni Recycled Water - Option 2A (25mgd PS @SSWWTP & 42" to Sabine Basin Wetland)		28,025	$61.7		2008										A									
Lake Tawakoni Recycled Water - Option 2B (55mgd PS @SSWWTP & 60" to Sabine Basin Wetland)		61,655	$138.5		2008										R									
Lake Tawakoni Recycled Water - Option 2C (125mgd PS @SSWWTP, 60" & 66" to Sabine Basin Wetlands)		140,125	$135.9		2008										R									
Love Field Corridor Direct Reuse		482	$6.4		2000			R																
TRA Las Colinas Reuse		7,000	$14.5	284	2012				R		R									R		R		
Red Bird Corridor Direct Reuse		695	$11.0		2000			R																
Southside WWTP Indirect Recycle to Lake Ray Hubbard		67,260	$201.3	205	2010			R		R								R						
TRA Dallas County Reuse		3,000	$21.8	157	2007						R													
White Rock Direct Recycle		18,497	$55.2	238	2010					R								R						
Existing Reservoirs																								
Sulphur River Basin																								
TRA Freestone County Reuse		6,760	$17.3	323	2012				R		R									R		R		
Wright-Patman Lake - Texarkana Purchase		134,520	$626.8	489	2010					A								A						
Cypress River Basin																								
Caddo Lake Enlargement																								
Sabine River Basin																								
Toledo Bend Reservoir (Option A)		200,659	$1,715.4	567	2010			A		A								A		A				
Toledo Bend Reservoir (Option B – Coop. Project, Dallas portion)		99,769	$475.7	401	2010			A		A								A		A				
Marvin Nichols Reservoir		472,300	$3,345.1	364	2012			R	R		R		R							R		R		
Tawakoni Increase by 1ft		5,350	$46.5		2008									A										
Tawakoni Increase by 3ft		14,000	$122.7		2008									A										
Tawakoni Increase by 5.5ft		25,000	$136.9		2008									A										
Neches River Basin																								
Sam Rayburn Reservoir / B.A. Steinhagen Lake		112,100	$1,287.6	733	2010			A		A								A						
Trinity River Basin																								
Additional Lake Ray Hubbard		158,440	$1.8		2011															R				
Tawakoni Balancing Reservoir Expansion			$19.0		2000			R																
Joe Pool: Modified use of Water Rights			$71.1		2012																R			
Joe Pool: Interruptible Water Rights			$0.0		2012																A			
Joe Pool: Reallocate Flood Pool Storage			$0.0		2012																A			
Joe Pool: Terminal Storage			$0.0		2012																A			
Waxahachie & Bardwell: Terminal Storage			$0.0		2012																A			
New Reservoirs																								
Red River Basin																								
Barkman Creek		10,800	-	na	2008								A											
Big Pine Reservoir		32,256	-	142	2008								A											
Bonham C of E (NTMWD)		38,961	-	246	2008	R	R						A											
Liberty Hill		30,240	-	239	2008								A											
Pecan Bayou		1,679	-	660	2008								A											
Ringgold		24,300	-	503	2008								R											

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Water Management Strategy for DWU from 2011 Region C and 2012 State Water Plans	Primary Responsibility	Projected Supply (ac-ft/yr)	Latest Capital Cost ($ Millions)	Unit Cost ($/ac-ft/yr)	Date of Cost Est.	1990 SWP (50yr)	1992 SWP	2000 LRWSP	2002 SWP	2005 LRWSP	2007 SWP	2007 Model	2008 Reservoir	2008 Tawakoni	2008 Tawakoni Recycle	2008 NTMWD & DWU	2009 4 County	2010 5-Yr Strategic Plan	2010 Dallas Delivery	2011 Region C	2012 Ellis & Johnson Study	2012 SWP	2014 LRWSP	
Sulphur River Basin																								
Lake Texoma – Authorized (Blend to NTMWD)		113,000	$336.4	496	2012			R			R									A		R		
Marvin Nichols I Reservoir (Option A – Coop. Project, Dallas Portion – to Lewisville Lake)		112,100	$393.4	261	2010			R	R	R			R					R						
Marvin Nichols I Reservoir (Option B – to Ray Roberts Lake)		112,100	$588.9	345	2010			R	R	A			R					A						
Marvin Nichols I Reservoir (Option C – to Lake Lavon)		112,100	$447.5	267	2010			R	R	A			R					A						
Marvin Nichols II Reservoir		280,100	-	89	2008				R				A											
TRA Ellis County Reuse		2,200	$10.4	505	2012				R		R									R		R		
Columbia	HDR	35,800	$180.0	536	2012					A			R					R		A		A		
Additional pipeline from Lake Tawakoni (2015)	HDR	77,994	$496.2	558	2012															R		R		
Mineola Reservoir	HDR																							
Tawakoni Enlargement	HDR																							
Cypress River Basin																								
Black Cypress		176,770	-	103	2008								A											
Little Cypress		144,900	-	150	2008	R	R						A											
Upper Little Cypress		71,700	-	-	2008								A											
Sabine River Basin																								
Big Sandy		46,600	-	132	2008	R	R						A											
Carl L. Estes		95,630	-	298	2008								A											
Carthage		537,000	-	68	2008								A											
Eight Mile		42,030	-	753	2008								A											
Highway 322		22,000	-	356	2008								A											
Kilgore		4,950	-	193	2008								A											
Mill Creek		12,000	-	653	2008								A											
Mineola Conservation Pool 403ft		93,000	$492.1		2008									A										
Mineola Conservation Pool 437.5ft		181,000	$888.2		2008									A										
Prairie Creek		17,215	-	248	2008								A											
Rabbit		3,500	-	-	2008								A											
Socagee		39,131	-	1,015	2008								A											
Stateline		280,000	-	-	2008								A											
New Lake Tawakoni Conservation Pool		79,515	$729.2		2008									A										
Tenaha		180,000	-	109	2008								A											
Waters Bluff		324,000	-	112	2008								A											
Neches River Basin																								
Cedar Creek		12,060	-	-	2008								A											
Cochino Bayou		123,300	-	-	2008								A											
Lake O' the Pines to NTMWD		87,900	$402.4	576	2012															A		A		
Eastex		75,290	$91.0		1992	R	R	R																
Ponta		84,442	-	309	2008								A											
Trinity River Basin																								
Big Elkhart		12,320	-	-	2008								A											
Boyd		4,792	-	-	2008								A											
Gail		12,379	-	669	2008								A											
Hurricane Bayou		17,900	-	377	2008								A											
Italy		44,800	-	244	2008								A											
Lower Keechi		25,662	-	639	2008								A											
Muenster (Upstream of Lake Ray Roberts)		385	$11.2	9,144	2007				R		R													
Roanoke		20,370	-	22,083	2008								A											
Tennessee Colony		405,800	-	420	2008								A											
Upper Keechi Creek		14,865	-	1,036	2008								A											
Groundwater and Conjunctive Use																								
Supplemental wells		-	$404.0	na	2007						R						R							
Lake O' the Pines to DWU	HDR	89,600	$541.5	705	2012					A								A		A		A		
Carrizo-Wilcox Groundwater		100,000	$801.5		2011															A				
Remote Well Field Development		17,711	$21.4		2008									A										
Roberts County Groundwater		200,000	$2,435.5		2011															A				
Transmission: Pumping and Balancing Storage																								
Ralph Hall		34,050	$286.4	727	2012						R		R							R		R		
Alta Mesa PS Expansion		22,420	$5.0		2007							R												
Arlington to Grand Prairie					2012																A			

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A = Alternative Evaluated but NOT Recommended

Water Management Strategy for DWU from 2011 Region C and 2012 State Water Plans	Primary Responsibility	Projected Supply (ac-ft/yr)	Latest Capital Cost ($ Millions)	Unit Cost ($/ac-ft/yr)	Date of Cost Est.	1990 SWP (50yr)	1992 SWP	2000 LRWSP	2002 SWP	2005 LRWSP	2007 SWP	2007 Model	2008 Reservoir	2008 Tawakoni	2008 Tawakoni Recycle	2008 NTMWD & DWU	2009 4 County	2010 5-Yr Strategic Plan	2010 Dallas Delivery	2011 Region C	2012 Ellis & Johnson Study	2012 SWP	2014 LRWSP	
Wilmer to Dallas Connection		1,095	$3.5	2,537	2009												R							
Constructed Wetland			$51.1		2008											A								
Constructed Wetland - NTMWD			$51.1		2008											R								
Constructed Wetland - DWU			$20.5		2008											R								
Conveyance Pipeline			$138.3		2008											A								
Conveyance Pipeline Branch to Lake Ray Hubbard			$4.8		2008											R								
Conveyance Pipeline to Branch			$105.2		2008											R								
Conveyance Pipeline to Outfall			$33.9		2008											R								
Conveyance Pump Station			$29.2		2008											R								
Cooper Reservoir to Irving		53,808	$54.0		1992	R	R																	
Cooper Reservoir to Lake Lavon		80,712	$70.0		1992	R	R																	
Dallas Supply to Ellis County Customers - Rockett SUD, Red Oak and Waxahachie		19,186	$13.6	568	2009												A							
East Fork Diversion PS			$10.1		2008											R								
Grand Prairie to Johnson Co SUD					2012																A			
IPL Connection - Scenario 1: Pipeline Directly to Bachman WTP			$1,481.0		2010														A					
IPL Connection - Scenario 2a: Joe Pool /Mountain Creek pass through			$1,400.0		2010														A					
IPL Connection - Scenario 2b: Through Joe Pool+ Naturally Available Storage			$1,400.0		2010														A		A			
IPL Connection - Scenario 2c: Through Joe Pool+ Naturally Available Storage+ Water Rights			$1,400.0		2010														R					
IPL Connection - Scenario 2d: Through Joe Pool+ Naturally Available Storage& Water Rights+ Mountain Creek Natural Storage					2010														A					
IPL Connection - Scenario 2e: Through Joe Pool+ Naturally Available Storage& Water Rights+ OCSF to Bachman WTP			$1,442+OCSF		2010														A					
IPL Connection - Scenario 2f: Through Joe Pool+ Naturally Available Storage& Water Rights+ OCSF to TRWD			$1,709+OCSF		2010														A					
IPL Connection - Scenario 3: Joe Pool/New 150mgd Southwest WTP			$421.0		2010														A					
IPL Connection - Scenario 3: Through Joe Pool+Naturally Available Storage+Water Rights and Relocated Frasier Dam			$1,420.0		2010														A					
IPL Connection - Scenario 4a: Elm Fork to West Fork Connection - Bidirectional Eagle Mountain to Lewisville			$1,753.0		2010														A					
IPL Connection - Scenario 4b: Elm Fork to West Fork Connection - Bidirectional Eagle Mountain to Lewisville+OCSF to TRWD			$1,794+OCSF		2010														A					
IPL Connection - Scenario 5: Through Joe Pool (Joe Pool Natural Storage & Water Rights) to proposed Southwest WTP			$1,662.0		2010														A					
IPL Turnout to Lake Bardwell					2012																A			
IPL Turnout to Lake Waxahachie					2012																A			
Lake Fork Reservoir to Tawakoni Balancing Reservoir		120,000	$363.0		2007	R	R	R	R	R	R													
Lake Joe Pool to Mansfield WTP					2012																A			
Lake O' the Pines to Sandy Creek		50,000	$99.7		2008									A										
Lake O' the Pines to Sandy Creek to Lake Fork, with flow from Lake Tawakoni		150,000	$295.6		2008									A										
Lake Palestine Connection (Integrated Pipeline w/ TRWD)	HDR	111,776	$888.0	773	2012	R	R	R		R	R									R		R		
Lake Sam Rayburn to Lake Palestine		127,794			2000			A																
Lake Lavon to Dallas County					2002				R															
Lake Lavon to Lewisville Lake					2002				R															
Lake Lewisville to Lake Eagle Mountain					2002				R															
Lake Waxahachie to Howard Rd WTP and Sokoll WTP (TRWD use of Terminal Storage)					2012																R			
Main Stem Diversion Pump Station			$10.7		2008											R								
Main Stem Diversion Pipeline			$28.2		2008											R								
Mansfield WTP expansion and connection to Joe Pool Lake					2012																R			
Mansfield to Grand Prairie					2012																A			
Mansfield to Johnson Co SUD					2012																A			
Marvin Nichols I Reservoir to Lavon Lake					2002				R															
Midlothian to Grand Prairie					2012																A			
Midlothian to Johnson Co SUD					2012																A			
New Bonham Reservoir to Lake Lavon			$37.0		1992	R	R																	
Oklahoma water to Lake Lavon (Option A)		112,100	$300.5	355	2010					A								R						
Oklahoma water to Lake Ray Roberts (Option B)		99,769	$494.6	463	2010					A								R						
Oklahoma water to Chapman Lake					2002				R															
Wright Patman - Reallocation of Flood Pool NTMWD		230,000	$1,433.5	797	2012															A		A		
Oklahoma water to Eagle Mountain Lake					2002				R															
Oklahoma Water to Irving		25,000	$194.8	810	2012																	R		
Pipeline - Main Stem Diversion PS to Wetland			$40.3		2008											A								
Pipeline - Tawakoni to Lake Ray Hubbard			$3.8		2008											R								
Main Stem Balancing Reservoir	HDR																							S
Joe Pool	HDR																							
Toledo Bend Project	CDM	200,000	$1,433.8	813	2012			A			R									A		A		
Southwest Treated Water Pipeline		336,300	$260.0		2011							R								R				
SS Pipeline to Lake Ray Hubbard			$64.7		2008											A								
SS Pipeline to Wetland			$19.4		2008											A								
SS Pump Station to Lake Ray Hubbard			$13.3		2008											A								
SS Pump Station to Wetland			$9.9		2008											A								
SSWWTP Pump Station			$20.8		2008											A								
System Infrastructure			$3.3		2008											R								

Appendix L: Identified and Evaluated Water Management Strategies

Legend
R = Recommended for Construction in Report
S = Identified and Studied New in the 2014 LRWSP
A = Alternative Evaluated but NOT Recommended

Water Management Strategy for DWU from 2011 Region C and 2012 State Water Plans	Primary Responsibility	Projected Supply (ac-ft/yr)	Latest Capital Cost ($ Millions)	Unit Cost ($/ac-ft/yr)	Date of Cost Est.	1990 SWP (50yr)	1992 SWP	2000 LRWSP	2002 SWP	2005 LRWSP	2007 SWP	2007 Model	2008 Reservoir	2008 Tawakoni	2008 Tawakoni Recycle	2008 NTMWD & DWU	2009 4 County	2010 5-Yr Strategic Plan	2010 Dallas Delivery	2011 Region C	2012 Ellis & Johnson Study	2012 SWP	2014 LRWSP	
Tawakoni Balancing Reservoir to East Side WTP		77,994	$496.2		2011			R												R				
Tawakoni Pump Station			$7.4		2008											R								
Toledo Bend Pipeline - Toledo Bend to Prairie Creek		50,000	$178.2		2008									A										
Toledo Bend Pipeline - 2 Stage from Toledo Bend to Prairie Creek to Lake Fork, with flow from Lake Tawakoni		150,000	$516.9		2008									A										
Wetland Transfer Pump Station			$6.9		2008											R								
Wetland Transfer Pipeline			$3.3		2008											R								
Wintergreen PS		224,200	$39.0		2007							R												
Wright Patman Lake (Coop. Project, Dallas portion – to Lewisville Lake)		130,036	$562.5	388	2010					A								R						
Water Treatment Plants: New and Expansions																								
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
100mgd WTP Expansion (Any plant)		56,050	$146.3		2011															R				
Arlington WTP Expansion(beyond 205mgd existing)					2012																A			
Mansfield WTP 15mgd Expansion (beyond 45mgd existing)		16,815	$28.1	658	2009												R				R			
Midlothian Tayman WTP Expansion (beyond 13mgd existing)					2012																A			
BachmanWTP Expansion to 130mgd		145,730	$22.0		2000			R																
East Side WTP Expansion to 540mgd (of 490mgd or 600mgd)		605,340	$71.5		2005			R		R														
Elm Fork WTP Expansion to 310mgd		347,510	$20.0		2000			R																
New 100mgd WTP		56,050	$190.1		2011															R				
New Regional WTP on Joe Pool					2012																A			
Sokoll WTP (Waxahachie & Rockett SUD; beyond 10mgd existing)		22,420	$97.7	678	2009												R				R			
SSWWTP Phosphorus Treatment			$0.6		2008											A								
Short-Term Supplies & Potential New Connections																								
Ralph Hall		29,219	$143.2	847	2012																	A		
Temporary connection for Wilmer to Hutchins for Dallas water		1,095	$2.5		2009												R							
No Longer Feasible and/or Not Affecting DWU Supplies																								
Bethesda WSC connection to Arlington		2,803	$15.5		2009												R							
TRA Kaufman County Reuse		1,000	$9.8	901	2012				R		R									R		R		
Cedar Creek/Richland-Chambers System to TRWD					2002				R															
Wright Patman - Reallocation of Flood Pool TRWD		180,000	$1,694.1	954	2012															A		A		
Conveyance Project - Indirect Reuse (TRA)		2,958																		R				
Conveyance Project - Toledo Bend (TRA)		4,067																		R				
Conveyance Project - TRWD Reservoir System (TRA)		11,015																		R				
Direct Reuse (UTRWD)		2,240	$11.3		2011															R				
Lower Bois d'Arc Creek		117,800	$615.5	972	2012				R		R		R							R		R		
Lake Livingston to DWU	HDR	200,000	$1,855.5	982	2012					A								A		A		A		
Indirect Reuse (TRA)		8,064																		R				
Lake George Parkhouse North to NTMWD		118,960	$516.6		2011															A				
Lake George Parkhouse South to NTMWD		108,480	$645.6		2011															A				
Lake Joe Pool - TRWD use of Terminal Storage					2012																R			
Lake Texoma - Authorized (Desalinate for NTMWD)		105,000	$796.5	994	2012			R												A		A		
TRWD Third Pipeline and Reuse		105,500	$914.4	1,016	2012						R									R		R		
Wright Patman - System Operation		298,000	$2,954.9	1,057	2012					A								A		A		A		
Lake Palestine to South East WTP		109,858	$540.9	313	2010			R		A								R						
Lake Ralph Hall - Indirect Reuse (UTRWD)		52,437	$286.4		2011															R				
Lake Ralph Hall (UTRWD)		34,050																		R				
Wright Patman - Texarkana Sale to NTMWD		150,000	$1,192.5	1,090	2012															A		A		
Lake Texoma - Not Authorized (Desalinate)	CDM	105,000	$925.9	1,099	2012			R												A		A		
Lake Livingston to NTMWD		200,000	$2,115.1	1,103	2012															A		A		
Tehuacana		56,800	$746.3	1,118	2012	R	R	R					R							A		A		
Lake Texoma (Option A)		12,100	$429.6	482	2010			R		A								A						
Lake Texoma (Option B)		81,048	$473.1	381	2010			R		A								R						
Lake Livingston to TRWD		200,000	$2,084.2	1,120	2012															A		A		
Wright Patman - Texarkana Sale to TRWD		100,000	$1,081.5	1,167	2012															A		A		
Mansfield supply to Johnson County SUD					2012																R			
Marvin Nichols Reservoir (NTMWD)		174,800	$830.9		2011															R				
Marvin Nichols Reservoir (TRWD)		280,000	$2,371.1		2011															R				
Marvin Nichols Reservoir (UTRWD)		35,000	$225.6		2011															R				
Mesa Groundwater		112,100	$1,758.3	570	2010					A								A						

Appendix L: Identified and Evaluated Water Management Strategies

Legend
R = Recommended for Construction in Report
S = Identified and Studied New in the 2014 LRWSP
A = Alternative Evaluated but NOT Recommended

Water Management Strategy for DWU from 2011 Region C and 2012 State Water Plans	Primary Responsibility	Projected Supply (ac-ft/yr)	Latest Capital Cost ($ Millions)	Unit Cost ($/ac-ft/yr)	Date of Cost Est.	1990 SWP (50yr)	1992 SWP	2000 LRWSP	2002 SWP	2005 LRWSP	2007 SWP	2007 Model	2008 Reservoir	2008 Tawakoni	2008 Tawakoni Recycle	2008 NTMWD & DWU	2009 4 County	2010 5-Yr Strategic Plan	2010 Dallas Delivery	2011 Region C	2012 Ellis & Johnson Study	2012 SWP	2014 LRWSP	
Midlothian to Johnson County SUD					2012																A			
Oklahoma Water to NTMWD, TRWD, UTRWD		115,000	$756.1	290	2012						R									R				
Purchase from Water Provider - TRWD Reservoir System (TRA)		11,133																		R				
Purchase from Water Provider - Chapman/Cooper Reservoirs (UTRWD)		5,815																		R				
Purchase from Water Provider - Indirect Reuse (TRA)		872																		R				
Purchase from Water Provider - Indirect Reuse (UTRWD)		3,260																		R				
Purchase from Water Provider - Joe Pool Reservoir (TRA)		74																		R				
Purchase from Water Provider - Lake Texoma (GTUA)		6,726																		R				
Purchase from Water Provider - Marvin Nichols Reservoir (TRA)		17,273																		R				
Purchase from Water Provider - Oklahoma (TRA)		269																		R				
Purchase from Water Provider - Ray Robert/Lewisville/Grapevine (UTRWD)		37,612																		R				
Purchase from Water Provider - Toledo Bend (TRA)		7,133																		R				
Purchase from Water Provider (1 to TRWD)		39,196																		R				
Purchase from Water Provider (2 to TRWD)		633																		R				
Roberts County Groundwater Project to NTMWD		200,000																		A				
South East WTP at 100mgd		112,100	$145.0		2000			R		R														
South East WTP expansion to 200mgd		224,200	$63.7		2000			R		R														
Tawakoni Balancing Reservoir to South East WTP			$55.5		2000			R																
Tehuacana Reservoir to Fort Worth		56,800	$746.3			R	R													R				
Carizo Wilcox Groundwater Project to DWU	HDR/TODD	100,000	$801.5	1,222	2012															A		A		S
Brazos Groundwater Project to NTMWD		100,000	$913.3	1,416	2012															A		A		
Sabine OCRs	HDR																							S
Conjunctive Use	HDR/TODD																							S
Upper Neches Project	HDR	112,100	$1,980.3	1,724	2012					R	R		R					R		R		R		S
Collin-Grayson Municipal Alliance system (GTUA)		27,412	$77.4	3,045	2012						R									R		R		
Fannin County Project (NTMWD)		5,113	$38.5	3,838	2012						R									R		R		
Lake Ralph Hall – Indirect Reuse		18,387	$0.0	na	2012															R		R		
TRA to Houston Contract		123,524																		R				
TRA to SJRA Contract		76,476																		R				
TRA to WUG Contract		28,672																		R				
Grayson County Project (GTUA)		24,640	$136.1	na	2012						R									R		R		
TRWD Third Pipeline and Reuse (TRA)		18,563																		R				
Wholesale Customer Conservation (GTUA)		4,958																		R				
Wholesale Customer Conservation (NTMWD)		80,372																		R				
Wholesale Customer Conservation (TRA)		14,551																		R				
Wholesale Customer Conservation (TRWD)		86,898																		R				
Wholesale Customer Conservation (UTRWD)		13,202																		R				
Main Stem PS (Add'l East Fork for NTMWD)		34,900	$0.0	na	2012															R		R		
TRA Denton Creek WWTP Reuse		3,750	$9.5	na	2012				R		R											R		
NTMWD interim purchase from DWU		11,200	$1.7		2012															A		A		
Lake Texoma (Interim purchase from GTUA for NTMWD)		21,900	$15.8		2012			R			R									R		R		
Sulfur River Basin Project	COE	435391	$2,744.9	2456	2012																			
Red Rim Supply to Big Pine	HDR																							

Appendix M

Strategy Names Corresponding to the Strategy Abbreviations

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Strategy Descriptions

Water Management Strategy	Full Description
Additional Conservation	Advanced Conservation (City of Dallas - Municipal only)
Main Stem PS & Bal Res	Main Stem Balancing Reservoir
Main Stem PS - NTMWD Swap Agreement	Main Stem Pump Station with NTMWD Swap Agreement
IPL – Part 1 Palestine Connection	Integrated Pipeline – Lake Palestine to Bachman Turnout
IPL – Part 2 Bachman Connection	Integrated Pipeline – Connection to Bachman WTP
Direct Reuse - Alt1	Direct Reuse - White Rock Alternative 1
Direct Reuse - Alt3	Direct Reuse - White Rock Alternative 3
CW Groundwater 2	Carrizo-Wilcox Groundwater Strategy 2
Neches Run-of-River	Neches Basin - Run-of-River Strategy
Direct Reuse - Bachman	Direct Reuse - Bachman Alternative
CW Groundwater 1	Carrizo-Wilcox Groundwater Strategy 1
Direct Reuse - Alt2	Direct Reuse - White Rock Alternative 2
Neches - Conj. - SysOp	Neches Basin - Conjunctive Strategy - System Operation
Neches - OCR -SysOp	Neches Basin - OCR Strategy -System Operation
Neches - OCR Stand Alone	Neches Basin - OCR Strategy - Stand Alone
Columbia	Lake Columbia (Eastex)
Neches-Conj. - Stand Alone	Neches Basin - Conjunctive Strategy - Stand Alone
Sabine - Conj. - SysOp	Conjunctive Use Strategy - Groundwater II & Smith 1B OCR
Red River OCR-2	Red River OCR Option 2
Red River OCR-1	Red River OCR Option 1
Rains OCR	Rains County OCR
Smith 2 OCR - Fork	Smith 2 - Delivery to Fork
Smith 2 OCR -Palestine	Smith 2 - Delivery to Palestine
Smith 1A OCR - Fork	Smith 1A - Delivery to Fork
Patman 232.5/MN 296.5	Lake Wright Patman and Lake Marvin Nichols (296.5) at designated Cons Pool Elevations
Smith OCR 1A - Palestine	Smith 1A - Delivery to Palestine
Lake Mineola	Lake Mineola
Patman 232.5/MN 313.5	Lake Wright Patman and Lake Marvin Nichols (313.5) at designated Cons Pool Elevations
Big Pine Reservoir	Big Pine Reservoir
Smith OCR 1B- Fork	Smith 1B - Delivery to Fork
Direct Potable Reuse	Direct Reuse of TRA Central Regional WWTP - DPR Strategy 1
Smith 1B OCR - Palestine	Smith 1B - Delivery to Palestine
Toledo Bend to Eastside	Toledo Bend to Eastside (Alt 1)

Strategy Descriptions

Water Management Strategy	Full Description
MN 328 / PH1	Lake Marvin Nichols (328) at designated Cons Pool Elevations and Lake George Parkhouse 1
MN 328 / PH2	Lake Marvin Nichols (328) at designated Cons Pool Elevations and Lake George Parkhouse 2
Lake O'The Pines	Lake O the Pines Pipeline
Lake Texoma	Lake Texoma
Ocean Desal	Ocean Desalination
Dredging	Lake Ray Hubbard Dredging
Toledo Bend to West System	Toledo Bend to Western System
Tawakoni Enlargement	Lake Tawakoni Enlargement - Option 1

Appendix N

UNRMWA / LNVA Settlement Agreement

(Related to the Neches Run-of-River Strategy)

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Vinson&Elkins

Molly Cagle mcagle@velaw com
Tel 512 542 8552 **Fax** 512 236 3280

June 29, 2010

City of Dallas
Attention: Director, Dallas Water Utilities Department
Dallas Water Utilities
1500 Marilla Street, 4AN
Dallas, Texas 75201

Re: **Executed Settlement Agreement**

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; Before the State Office of Administrative Hearings

SOAH Docket No. 582-10-0158; TCEQ Docket No. 2009-0506-WR
City of Lufkin's Application for Amendment to Certificate of Adjudication No. 06-4411; Before the State Office of Administrative Hearings

Dear Sir/Madame:

Pursuant to Paragraph 10 of the Settlement Agreement, LNVA hereby promptly distributes a fully executed copy of the Agreement to the Parties. The effective date of the Settlement Agreement is June 23, 2010.

Thank you.

Very truly yours,

Molly Cagle

Molly Cagle

Enclosure(s)

cc: Gwendolyn Hill Webb
Stephen Webb
Webb & Webb
P.O. Box 1329
Austin, Texas 78767-1329

SETTLEMENT AGREEMENT

THIS SETTLEMENT AGRFEMENT (this "Agreement") dated as of June 23, 2010, (in accordance with Paragraph 10 below, the "Effective Date"), by and between the Lower Neches Valley Authority ("LNVA"), with an address at Post Office Box 5117, Beaumont, Texas 77726-5117, and the City of Lufkin ("Lufkin"), with an address at Post Office Box 190, Lufkin, Texas 75902-0190 (collectively, "Applicants"), and the City of Tyler ("Tyler"), with an address at Post Office Box 2039, Tyler, Texas 75710-2039, the City of Dallas ("Dallas"), with an address at 1500 Marilla Street, 4AN, Dallas, Texas 75201, Upper Neches River Municipal Water Authority ("UNRMWA"), with an address at Post Office Box 1965, Palestine, Texas 75802-1965, Nacogdoches County (the "County"), with an address at 101 West Main Street, Nacogdoches, Texas 75961, the City of Nacogdoches ("Nacogdoches"), with an address at Post Office Drawer 635030, Nacogdoches, Texas 79563, the Angelina and Neches River Authority ("ANRA"), with an address at Post Office Box 387, Lufkin, Texas 75902, the City of Jacksonville ("Jacksonville"), with an address at Post Office Box 1390, Jacksonville, Texas 75766, and the City of Whitehouse ("Whitehouse"), with an address at Post Office Box 776, Whitehouse, Texas 75791 (each a "Protestant," collectively, "Protestants")(Applicants and Protestants, each a "Party" and collectively, the "Parties").

RECITALS

On December 19, 2007 LNVA filed an application to amend Certificate of Adjudication Number 06-4411F (the "LNVA Permit") with the Texas Commission on Environmental Quality ("TCEQ" or the "Commission") seeking an amendment of Special Conditions 5.C. and 5.D. (the "LNVA Application").

On June 19, 2008 Lufkin filed an application to amend Certificate of Adjudication Number 06-4411II (the "Lufkin Permit") with TCEQ, seeking an amendment of Special Conditions 5.C. and 5.D. (the "Lufkin Application").

The Executive Director of the Commission published a draft permit in response to the LNVA Application (the "LNVA Draft Permit").

The Executive Director of the Commission published a draft permit in response to the Lufkin Application (the "Lufkin Draft Permit").

Protestants filed comments and/or requested a contested case hearing on the LNVA Application and the Lufkin Application, which hearing requests were granted by the TCEQ and referred to the State Office of Administrative Hearings.

Protestants were admitted as parties to the consolidated hearing to consider the LNVA Application and the Lufkin Application in SOAH Docket No. 582-10-0159; TCEQ Docket No. 2009-0168-WR; and SOAH Docket No. 582-10-0158; TCEQ Docket No. 2009-0506-WR, respectively (the "Hearing").

Protestants and Applicants have reached an agreement on amendments to the LNVA Permit and the Lufkin Permit.

Applicants and Protestants desire to execute this Agreement so that no facts or issues remain controverted.

Based on the recitals stated above, and for and in consideration of the promises and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the Parties agree as follows:

1. **<u>Joint Motion to Remand</u>.** Within five (5) days of the Effective Date, LNVA shall file a Joint Motion to Remand on behalf of all the Parties requesting that, pursuant to 30 TEX.

ADMIN. CODE § 80.101, the Administrative Law Judge remand the LNVA Application and the Lufkin Application to the Executive Director for issuance of amendments to the LNVA Permit and the Lufkin Permit incorporating the permit terms in Paragraphs 2 and 3 of this Agreement. By executing this Agreement, the Parties authorize LNVA to execute and file the Joint Motion to Remand on their behalf, provided it is substantially in the form attached hereto as Exhibit A.

2. **Special Condition 5.C.** The Parties hereby agree that they support the amendment of Special Condition 5.C. as follows:

   a. For the LNVA Permit:

   5.C. Excepting municipal purposes, all of owner's right to divert and use public water under the priority date of November 12, 1963 is subordinate to any existing municipal water rights granted by the Commission with a priority date between November 13, 1963 and January 3, 2008.

   b. For the Lufkin Permit:

   5.C. Excepting municipal purposes, all of owner's right to divert and use public water under the priority date of November 12, 1963 is subordinate to any existing municipal water rights granted by the Commission with a priority date between November 13, 1963 and August 14, 2008.

3. **Special Condition 5.D.** The Parties hereby agree that, in lieu of the modifications to Special Condition 5.D. shown in the LNVA Draft Permit and the Lufkin Draft Permit, the Applicants request and the Protestants support the amendment of Special Condition 5.D. in the LNVA Permit and the Lufkin Permit as follows:

   Owner's rights, under the priority date of November 12, 1963, authorized by this certificate of adjudication, shall be subordinate to:

(1) all existing rights granted by the Commission with a priority date between November 13, 1963 and [January 3, 2008[1] / August 14, 2008[2]] to impound, divert, and/or use waters in and above the proposed Ponta Dam on the Angelina River;

(2) all existing rights and any rights hereafter granted by the Commission to impound, divert, and/or use waters at or above the Weches Dam site on the Neches River herein defined as Latitude 31.569553 deg N, Longitude 95.150500 deg W on the Neches River;

(3) any rights hereafter granted by the Commission to impound, divert, and/or use waters on Mud Creek above Mud Creek's confluence with the Angelina River;

(4) all existing rights and any rights hereafter granted by the Commission to impound, divert, and/or use the waters of Naconiche Creek and/or any of its tributaries upstream of the point at which Highway 59 crosses Naconiche Creek herein defined as Latitude 31.766667 deg N, Longitude 94.566111 W on Naconiche Creek, if, but only if, all use and any reuse of such waters remains entirely within the Angelina-Neches River Basins and all return flows associated with such use and reuse remain entirely in the Angelina-Neches River Basins; and

(5) The City of Nacogdoches's existing water right under both Certificate of Adjudication 06-4864, with priority dates of January 5,1970 and June 27, 1977, issued February 19, 1987, and Certificate of Adjudication 06-4864A, issued June 17, 1988, and up to a total of thirty-four thousand, four hundred and sixteen (34,416) acre-feet annually of water rights hereafter granted by the Commission to the City of Nacogdoches, if, but only if, all use and any reuse of such water remains entirely within the Angelina-Neches River Basins and all return flows associated with such use remains entirely in the Angelina-Neches River Basins, and provided that the quantity of such continued subordination shall be reduced by the amount of surface water that the City of Nacogdoches hereafter obtains by contract from sources within the Angelina-Neches River Basins.

4. **Alternative Settlement Procedure.** If for any reason this Agreement is not effective by June 20, 2010, thereby jeopardizing the ability to remand the LNVA Application and the Lufkin Application to the Executive Director pursuant to 30 TEX. ADMIN. CODE § 80.101, the Parties executing this Agreement agree to attempt to effectuate the terms of this Agreement through an alternative procedure, which would be coordinated with the

[1] For the LNVA Water Rights Amendment.

[2] For the Lufkin Water Rights Amendment.

Applicants at the time; Protestants acknowledge such alternative procedure may require motions to amend and withdraw testimonies and may require the Protestants to remain in the Hearing for the sole purpose of assuring that the terms of the settlement are achieved.

5. **Additional Application by LNVA**. Protestants acknowledge that LNVA plans to submit an application to TCEQ to authorize the storage and appropriation of an additional 28,000 acre-feet per year of water, **resulting from the 1969 reallocation of flood water to conservation storage**. Protestants, except Tyler, may request a hearing on such application and, as necessary, may seek party status in such hearing in order to confirm (A) that any draft permit published in response to such application authorizes only the additional 28,000 acre-feet per year of water **resulting from the 1969 reallocation of flood water to conservation storage and (B) that the** additional storage and appropriation of the 28,000 ac-feet per year is subject to the subordination provisions in Special Condition 5.C. set forth in Paragraph 2 above and Special Condition 5.D. set forth in Paragraph 3, above. If the draft permit conforms to these conditions, then Protestants agree to support LNVA's application.

6. **Additional Application by Lufkin**. Protestants acknowledge that Lufkin plans to submit an application to TCEQ to add municipal use by Lufkin and its customers in the Angelina-Neches River Basins as a permitted use for water authorized to be stored, diverted and used under Certificate of Adjudication No. 06-4393. Protestants, except Tyler, may request a hearing on such application and, as necessary, seek party status in order to confirm that any draft permit published in response to such application (A) is limited to the municipal use amendment(s), and (B) does not make any other amendment to Certificate of Adjudication No. 06-4411, as amended. If the draft permit conforms to these conditions then Protestants agree to support Lufkin's amendment application.

7. **Agreements by and among Applicants and Tyler**.

   a. **Tyler Application**. Applicants shall not file adverse comments, request a contested case hearing or seek party status in any contested case hearing regarding, or otherwise oppose, any application filed by Tyler under Texas Water Code Section 11.042 (2010) for reuse and diversions of waters, provided that such diversions occur above Mud Creek's confluence with the Angelina River.

   b. **Additional LNVA Application**. Tyler shall not file adverse comments, request a contested case hearing or seek party status in any contested case hearing regarding, or otherwise oppose, LNVA's anticipated system operation or other application(s) to amend its existing water right permit or to seek a water right permit to the extent such applications(s) request:

      i. storage and appropriation of an additional 28,000 acre-feet per year of water[3] (so long as such additional water is subject to the revised Special Condition 5D set forth in Paragraph 3 above);

      ii. that LNVA's existing run of river rights in Pine Island Bayou and the Neches River, with priority dates of August 12, 1913, November 8, 1913 and December 31, 1924, be backed by LNVA's stored water in B.A. Steinhagen and Sam Rayburn Reservoirs to achieve 100% reliability; and

      iii. authorization to divert and use unappropriated run of river flows below Sam Rayburn and B.A. Steinhagen Reservoirs, when such unappropriated run of

[3] This represents the additional yield in Sam Rayburn Reservoir resulting from the 1969 reallocation of flood water to conservation storage.

river flows are available, in lieu of calling on stored water.

c. **Additional Lufkin Application**. Tyler shall not file adverse comments, request a contested case hearing or seek party status in any contested case hearing regarding, or otherwise oppose, Lufkin's anticipated application(s) to amend its Certificate of Adjudication No. 06-4393 to add municipal use by Lufkin and its customers in the Angelina-Neches River Basins as a permitted use for water authorized to be stored, diverted and used thereunder to the extent the municipal use amendment(s) are all that is requested.

8. **Notice of Execution**. Each Party shall notify each of the other Parties of its execution of this Agreement. Such notification may be made by facsimile or email in accordance with the certificate of service for the Hearing in lieu of the requirements of paragraph 13 below. Each Party shall promptly provide to LNVA a copy of their respective executed signature page for this Agreement by fax or email, with ten (10) original signature pages to follow immediately.

9. **Authority to Execute**. Each signatory hereby represents that he/she is duly authorized to make and execute this Agreement on behalf of his or her Party.

10. **Effective Date**. This Agreement is effective upon execution by all of the Parties. LNVA shall fill in the Effective Date upon execution by all Parties and promptly distribute a fully executed copy of this Agreement to the Parties upon receipt of the last notice and accompanying signatures under Paragraph 8.

11. **Benefit**. This Agreement and all of the obligations and rights herein established shall extend to and be binding upon and shall inure to the benefit of the respective successors and assigns of the respective Parties.

12. **Further Assurances**. Each Party agrees to execute and deliver all such other and additional instruments and documents and to do such other acts and things as may be reasonably necessary more fully to effectuate the terms and provisions of this Agreement.

13. **Notices**. All notices issued pursuant to this Agreement shall be delivered in writing at the addresses as noted below and shall be considered effective upon receipt by the receiving Party.

Lower Neches Valley Authority
Attention: General Manager
Post Office Box 5117
Beaumont, Texas
77726-5117

City of Lufkin
Attention: City Manager
Post Office Box 190
Lufkin, Texas 75902-0190

City of Tyler
Post Office Box 2039
Tyler, Texas 75710-2039

City of Dallas
Attention: Director Dallas Water Utilities Department
Dallas Water Utilities
1500 Marilla Street, 4AN
Dallas, Texas 75201

Upper Neches River Municipal Water Authority
Attention: General Manager
Post Office Box 1965
Palestine, Texas 75802-1965

Nacogdoches County
Attention: Land and Special Projects Agent
101 West Main Street
Nacogdoches, Texas 75961

City of Nacogdoches
Attention: City Manager
Post Office Drawer 635030
Nacogdoches, Texas 79563

Angelina and Neches River Authority
Attention: General Manager
Post Office Box 387
Lufkin, Texas 75902

City of Jacksonville
Attention: City Manager
Post Office Box 1390
Jacksonville, Texas 75766

City of Whitehouse
Attention: City Manager
Post Office Box 776
Whitehouse, Texas 75791

14. **Headings**. Paragraph headings in this Agreement are inserted only for convenient reference and are not to be given any effect in construing this Agreement.

15. **Choice of Law**. This Agreement is to be construed, interpreted, and enforced under the laws of the State of Texas, without regard to any conflicts of law provision that would direct the application of the substantive laws of any other jurisdiction.

16. **Counterparts**. This Agreement may be signed in separate counterparts by each Party, which taken together shall constitute an original Agreement.

17. **Entire Agreement**. The Parties agree that this Agreement sets forth all the promises and agreements between them and supersedes all prior and contemporaneous agreements, understandings, inducements, or conditions, whether expressed or implied, and whether oral or written. No modifications, amendments, or changes to this Agreement shall be valid unless in writing and signed by an authorized representative of the Parties.

LOWER NECHES VALLEY
AUTHORITY

By: ______________________
President

STATE OF TEXAS §
§
COUNTY OF JEFFERSON §

BEFORE ME, the undersigned authority, on this day personally appeared Steven McReynolds in his capacity as authorized representative of Lower Neches Valley Authority, known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 16th day of June, 2010.

ANNETTE PURINGTON
Notary Public, State Of Texas
My Commission Expires
03-22-2012

____
Notary Public, State of Texas

CITY OF LUFKIN

By: Paul L. Parker
Title

STATE OF TEXAS §
§
COUNTY OF Angelina §

BEFORE ME, the undersigned authority, on this day personally appeared Paul C. Parker, in his/her capacity as authorized representative of the City of Lufkin known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 8th day of June, 2010.

Kara Denise Atwood
Notary Public, State of Texas

NOTARY PUBLIC STATE OF TEXAS
KARA DENISE ATWOOD
Notary Public State of Texas
My Commission Expires
01 - 28 - 2011

CITY OF TYLER

By: L Scott Wall, ACM for GM/GM C.M.
Title Ass't City Manager
CC 5-26-10

STATE OF TEXAS §
§
COUNTY OF Smith §

BEFORE ME, the undersigned authority, on this day personally appeared L Scott Wall, in his/her capacity as authorized representative of the City of Tyler known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 15th day of June, 2010.

DARCEL VEAL THOMPSON
NOTARY PUBLIC STATE OF TEXAS
COMMISSION EXPIRES:
01-22-2012

Darcel Veal Thompson
Notary Public, State of Texas

CITY OF DALLAS

By: [signature]
Jo M. (Jody) Puckett, P.E.
Title: Director, Water Utilities Department

Submitted to City Attorney

STATE OF TEXAS §
§
COUNTY OF Dallas §

BEFORE ME, the undersigned authority, on this day personally appeared Jo M. Puckett, in his/her capacity as authorized representative of the City of Dallas known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 22nd day of June, 2010.

[signature]
Notary Public, State of Texas

DIANN JERNIGAN
Notary Public
State of Texas
My Comm. Exp. 10-20-2011

UPPER NECHES RIVER
MUNICIPAL WATER
AUTHORITY

Monty D. Shank

By: ______________________
General Manager

STATE OF TEXAS §
§
COUNTY OF ANDERSON §

BEFORE ME, the undersigned authority, on this day personally appeared MONTY D. SHANK, in his/her capacity as authorized representative of the Upper Neches River Municipal Water Authority known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 15 day of JUNE, 2010.

____
Notary Public, State of Texas

NOTARY PUBLIC STATE OF TEXAS
GINA L. BLACK
My Commission Expires
May 26, 2012

NACOGDOCHES COUNTY

By: ____________________________
Title Joe English, County Judge

STATE OF TEXAS §
§
COUNTY OF Nacogdoches §

BEFORE ME, the undersigned authority, on this day personally appeared Joe English, in his/her capacity as authorized representative of Nacogdoches County known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 16 day of June, 2010.

CAROL A MOON
Notary Public
STATE OF TEXAS
My Comm. Exp. 04/21/2013

Carol A. Moon
Notary Public, State of Texas

CITY OF NACOGDOCHES

By: ______________________
Jim Jeffers, City Manager

STATE OF TEXAS §
§
COUNTY OF Nacogdoches §

BEFORE ME, the undersigned authority, on this day personally appeared Jim Jeffers, in his/her capacity as authorized representative of the City of Nacogdoches known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 9 day of June, 2010.

____
Notary Public, State of Texas

JAN PIGG
Notary Public, State of Texas
My Commission Expires
June 06, 2011

ANGELINA AND NECHES
RIVER AUTHORITY

By: Julie Dowell
Title **President**

STATE OF TEXAS §
§
COUNTY OF Angelina §

BEFORE ME, the undersigned authority, on this day personally appeared Julie Dowell, in his/her capacity as authorized representative of the Angelina and Neches River Authority known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 17 day of June, 2010.

TERESA SCROGGINS
Notary Public State of
My Commission Expires
October 10, 2013

Teresa J Scroggins
Notary Public, State of Texas

CITY OF JACKSONVILLE

By: [signature]

Title City Manager

STATE OF TEXAS §
§
COUNTY OF Cherokee §

BEFORE ME, the undersigned authority, on this day personally appeared Mo Raissi, in his/her capacity as authorized representative of the City of Jacksonville known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 17th day of June, 2010.

[signature] Carol Rhymes

Notary Public, State of Texas

CAROL RHYMES
NOTARY PUBLIC
STATE OF TEXAS
My Commission Expires 12-23-2013

CITY OF WHITEHOUSE

By: [illegible signature]

Title: Interim City Mgr

STATE OF TEXAS §
§
COUNTY OF Smith §

BEFORE ME, the undersigned authority, on this day personally appeared Mike Peterson, in his/her capacity as authorized representative of the City of Whitehouse known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he/she executed the same for the purposes and consideration therein expressed.

Given under my hand and seal of office this 23rd day of June, 2010.

Susan Hargis

Notary Public, State of Texas

SUSAN HARGIS
MY COMMISSION EXPIRES
August 10, 2012

EXHIBIT

tabbles

A

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	§ § § § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

SOAH DOCKET NO. 582-10-0158
TCEQ DOCKET NO. 2009-0506-WR

CITY OF LUFKIN'S APPLICATION FOR AMENDMENT TO CERTIFICATE OF ADJUDICATION NO. 06-4411	§ § § § §	**BEFORE THE STATE OFFICE OF ADMINISTRATIVE HEARINGS**

JOINT MOTION FOR REMAND

TO: THE HONORABLE ADMINISTRATIVE LAW JUDGE

COMES NOW Applicants Lower Neches Valley Authority ("LNVA") and the City of Lufkin ("Lufkin") (collectively, "Applicants"), the Upper Neches River Municipal Water Authority, the City of Dallas, Nacogdoches County, the City of Tyler, the City of Nacogdoches, the Angelina and Neches River Authority, the City of Jacksonville and the City of Whitehouse (collectively, "Protestants") (Applicants and Protestants, collectively, "Movants"), and file this Unopposed Joint Motion to Remand the above-referenced proceedings pursuant to 30 TEX. ADMIN. CODE § 80.101.

In support of the motion, Movants would show the following:

On June 23, 2010 a settlement agreement became effective between Applicants and Protestants. There are no additional protesting parties in this proceeding.

LNVA and Lufkin applied for amendments to Certificates of Adjudication ("CoA") No. 06-4411F and H, respectively, modifying the terms of Special Conditions 5.C. and 5.D. Pursuant to the settlement agreement, Protestants support the proposed amendment to Special Condition 5.C. as set forth in the Draft Permits prepared and recommended by the TCEQ for the LNVA and Lufkin CoAs at issue in these proceedings. For the LNVA CoA No. 06-4411F, amended Special Condition 5.C. is:

> 5.C. Excepting municipal purposes, all of owner's right to divert and use public water, under the priority date of November 12, 1963, is subordinate to any existing municipal water rights granted by the Commission with a priority date between November 13, 1963 and January 3, 2008.

For the Lufkin CoA No. 06-4411H, amended Special Condition 5.C. is:

> 5.C. Excepting municipal purposes, all of owner's right to divert and use public water, under the priority date of November 12, 1963, is subordinate to any existing municipal water rights granted by the Commission with a priority date between November 13, 1963 and August 14, 2008.

Also pursuant to the settlement agreement, Applicants request, and Protestants support, that in lieu of the modifications to Special Condition 5.D. shown in the LNVA Draft Permit and the Lufkin Draft Permit, the following new Special Condition 5.D. be incorporated into the Applicants' CoAs:

> Owner's rights, under the priority date of November 12, 1963, authorized by this certificate of adjudication, shall be subordinate to:
>
> (1) all existing rights granted by the Commission with a priority date between November 13, 1963 and [January 3, 2008[1] / August 14, 2008[2]] to impound, divert, and/or use waters in and above the proposed Ponta Dam on the Angelina River;

---

[1] For the LNVA Water Rights Amendment.

[2] For the Lufkin Water Rights Amendment

(2) all existing rights and any rights hereafter granted by the Commission to impound, divert, and/or use waters at or above the Weches Dam site on the Neches River herein defined as Latitude 31.569553 deg N, Longitude 95.150500 deg W on the Neches River;

(3) any rights hereafter granted by the Commission to impound, divert, and/or use waters on Mud Creek above Mud Creek's confluence with the Angelina River;

(4) all existing rights and any rights hereafter granted by the Commission to impound, divert, and/or use the waters of Naconiche Creek and/or any of its tributaries upstream of the point at which Highway 59 crosses Naconiche Creek herein defined as Latitude 31.766667 deg N, Longitude 94.566111 W on Naconiche Creek, if, but only if, all use and any reuse of such waters remains entirely within the Angelina-Neches River Basins and all return flows associated with such use and reuse remain entirely in the Angelina-Neches River Basins; and

(5) The City of Nacogdoches's existing water right under both Certificate of Adjudication 06-4864, with priority dates of January 5,1970 and June 27, 1977, issued February 19, 1987, and Certificate of Adjudication 06-4864A, issued June 17, 1988, and up to a total of thirty-four thousand, four hundred and sixteen (34,416) acre-feet annually of water rights hereafter granted by the Commission to the City of Nacogdoches, if, but only if, all use and any reuse of such water remains entirely within the Angelina-Neches River Basins and all return flows associated with such use remains entirely in the Angelina-Neches River Basins, and provided that the quantity of such continued subordination shall be reduced by the amount of surface water that the City of Nacogdoches hereafter obtains by contract from sources within the Angelina-Neches River Basins.

The Executive Director of the Texas Commission on Environmental Quality previously approved Special Condition 5.C. above, and has reviewed new Special Condition 5.D. above, and is satisfied that it could issue amendments to CoA No. 06-4411 F and H, respectively, incorporating such terms. Therefore, there are no contested issues remaining for resolution by SOAH. The Movants, therefore, respectfully request that, pursuant to 30 TEX. ADMIN. CODE § 80.101, the Administrative Law Judge remand these matters to the Executive Director.

Respectfully submitted on behalf of Movants,

Molly Cagle
State Bar No. 03591800
Paulina Williams
State Bar No. 24066295
Vinson & Elkins LLP
2801 Via Fortuna, Suite 100
Austin, Texas 78746
Telephone: (512) 542-8552
Facsimile: (512) 542.8612

ATTORNEYS FOR APPLICANT LOWER NECHES VALLEY AUTHORITY

CERTIFICATE OF CONFERENCE

I certify that representatives for each of the Movants have consented to this Joint Motion to Remand. In the interest of efficiency, representatives of Movants have dispensed with individual signature pages, and have instead authorized LNVA to file this Joint Motion to Remand on their behalf. Representatives for TCEQ's Executive Director and the Office of Public Counsel ("OPIC") have indicated that the Executive Director and OPIC are not opposed to this Joint Motion to Remand.

Molly Cagle
Molly Cagle

:

CERTIFICATE OF SERVICE

I certify that a true and correct copy of the foregoing document has been served on the following via electronic mail on this the 25th day of June, 2010.

FOR THE EXECUTIVE DIRECTOR:

Robin Smith, Staff Attorney
Christiaan Siano, Staff Attorney
Texas Commission on Environmental Quality
Environmental Law Division P.O. Box 13087, MC 173
Austin, Texas 78711-3087
Tel: 512.239.0463 (RS)
Tel: 512.239.6743 (CS)
Via Facsimile: 512.239.0606
Email: rsmith@tceq.state.tx.us
Email: csiano@tceq.state.tx.us

FOR PUBLIC INTEREST COUNSEL:

Mr. Garrett Arthur, Attorney
Texas Commission on Environmental Quality
Public Interest Counsel, MC-103
P.O. Box 13087
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Tel: 512.239.6363
Facsimile: 512.239.6377
Email: garthur@tceq.state.tx.us

FOR ANGELINA & NECHES RIVER AUTHORITY, CITY OF JACKSONVILLE, AND CITY OF WHITEHOUSE

John D. Stover
P.O. Box 1728
Lufkin, Texas 75902-1728
Facsimile: 936.632.6545
Email: jstover@zeleskey.com

UPPER NECHES RIVER MUNICIPAL WATER AUTHORITY AND NACOGDOCHES COUNTY

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Lloyd Gosselink Rochelle & Townsend PC
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CITY OF TYLER AND TYLER WATER UTILITIES

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CITY OF LUFKIN, TEXAS

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OFFICE OF THE CHIEF CLERK

Ms. LaDonna Castañuela
Texas Commission on Environmental Quality
Office of the Chief Clerk, MC 105
P.O. Box 13087
Austin, Texas 78711-3087

Paulina Williams

Appendix O

Costing Assumptions and Methodologies

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2014 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 2014 Dallas LRWSP uses the UCM and similar assumptions as those used in development of the 2016 Regional Plans in order 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, e.g. 5.5% interest for 30 years for debt service calculations. For each potential strategy, a planning level costing analysis was developed using the UCM. All costs are estimated based on September 2013 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.
- HDR selected the UCM for the LRWSP adjusted with a few Dallas specific assumptions e.g. 5.5% interest for 30 years for debt service calculations.
- 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 2013 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 5.5% for 30 years for all facilities with 30 year financing being consistent with DWU bond terms.
  - Energy costs for pumping water were estimated based on an average rate of $0.08/kW-hr, a 2016 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 2012 rural land value 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 5.5% for 30 years for all facilities to be consistent with DWU bond terms. Energy costs for pumping are estimated based on an average energy cost of $0.08/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 4% 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 1% 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 2012 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.

http://www.twdb.texas.gov/waterplanning/rwp/planningdocu/2016/doc/current_docs/project_docs/20131210Unified_Costing_Model.xlsb

The UCM User's Guide can be obtained at the following URL.

http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1148321307_UnifiedCostingModelUsersGuide.pdf

[1] http://recenter.tamu.edu/data/rland/

The following figures provide examples of the modules contained in the UCM and used in the 2014 Dallas LRWSP.

Figure 1. UCM Reference Flow Chart

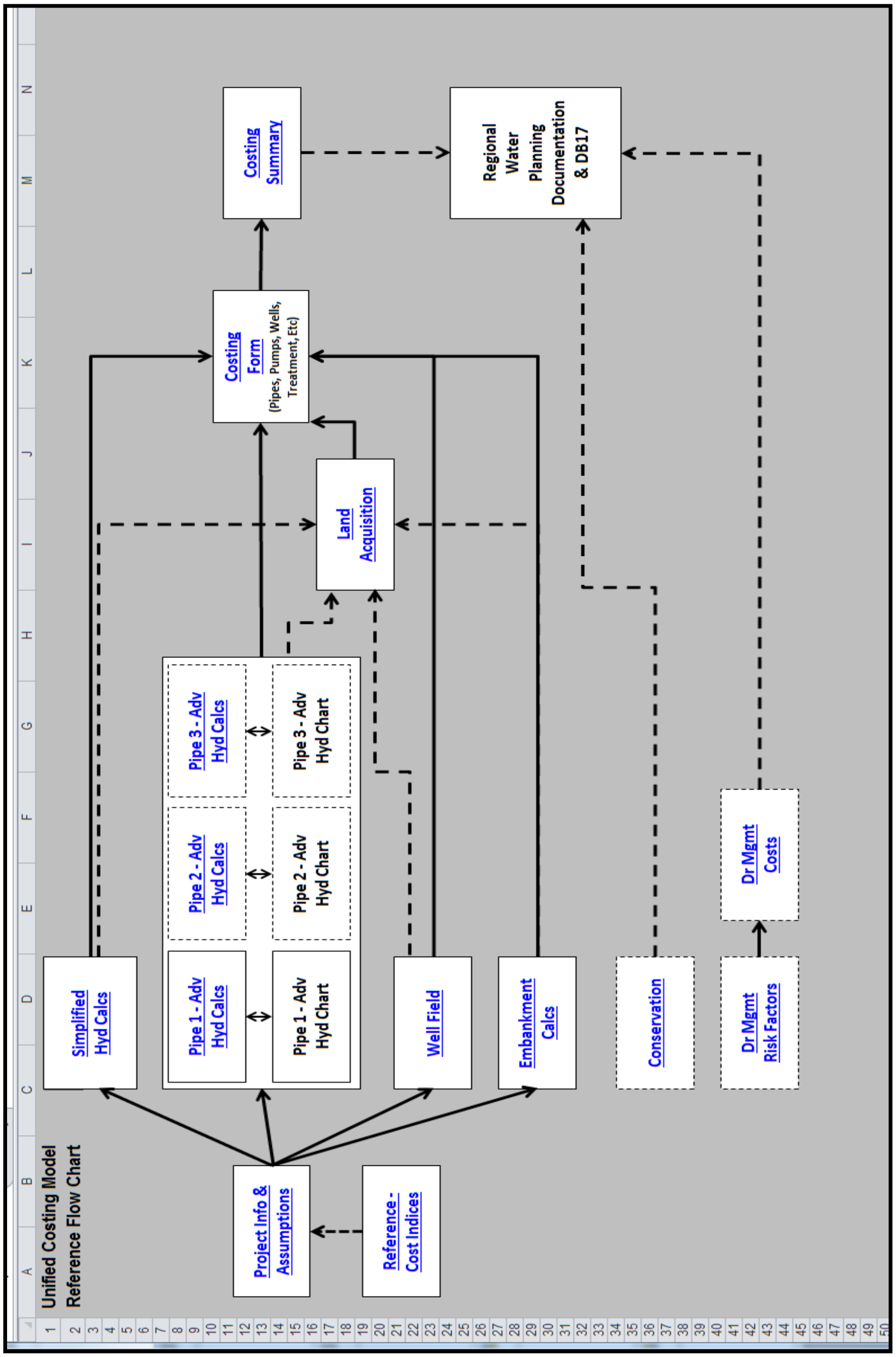


Figure 2. UCM Basic Information and Assumptions Module

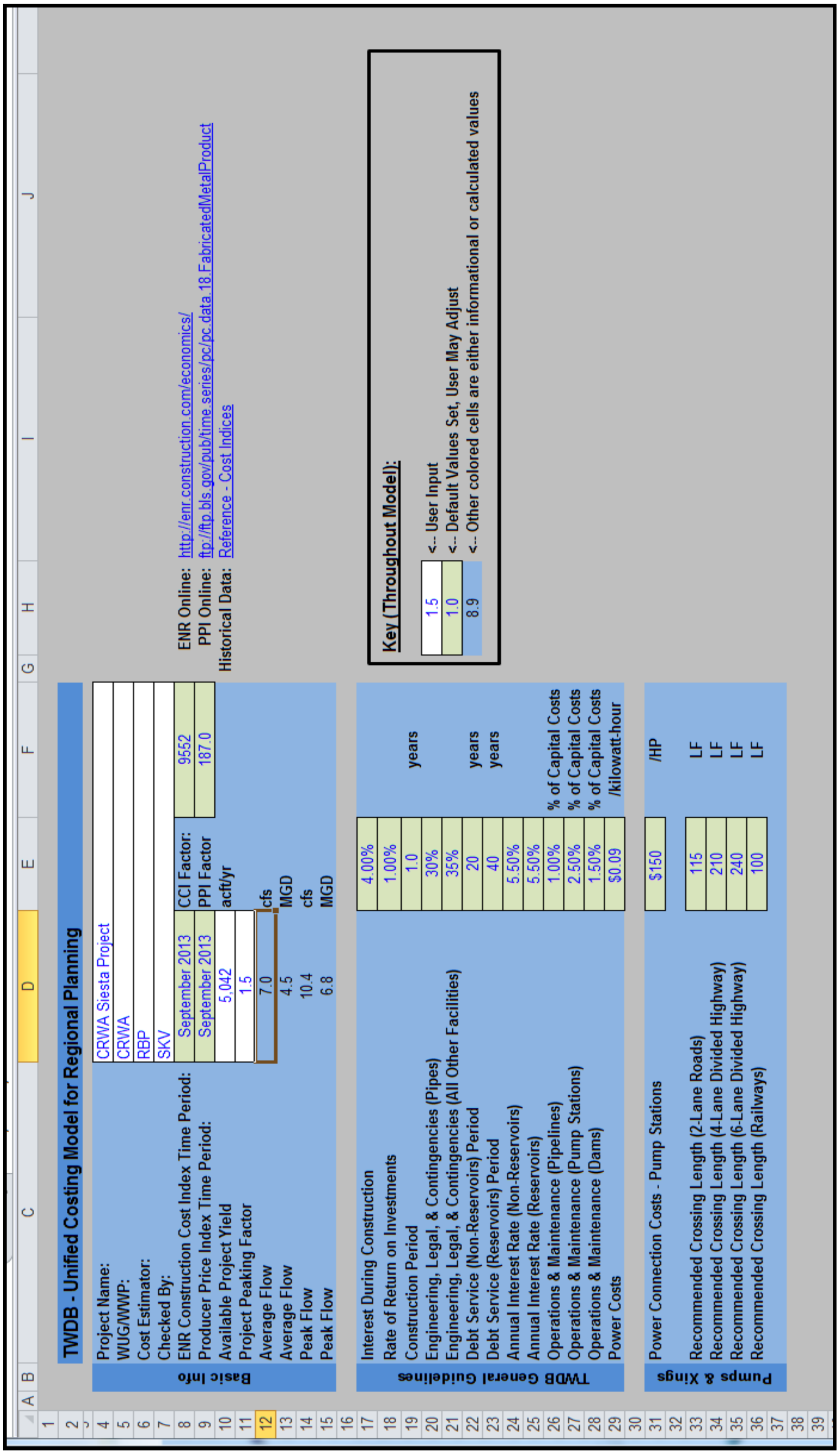
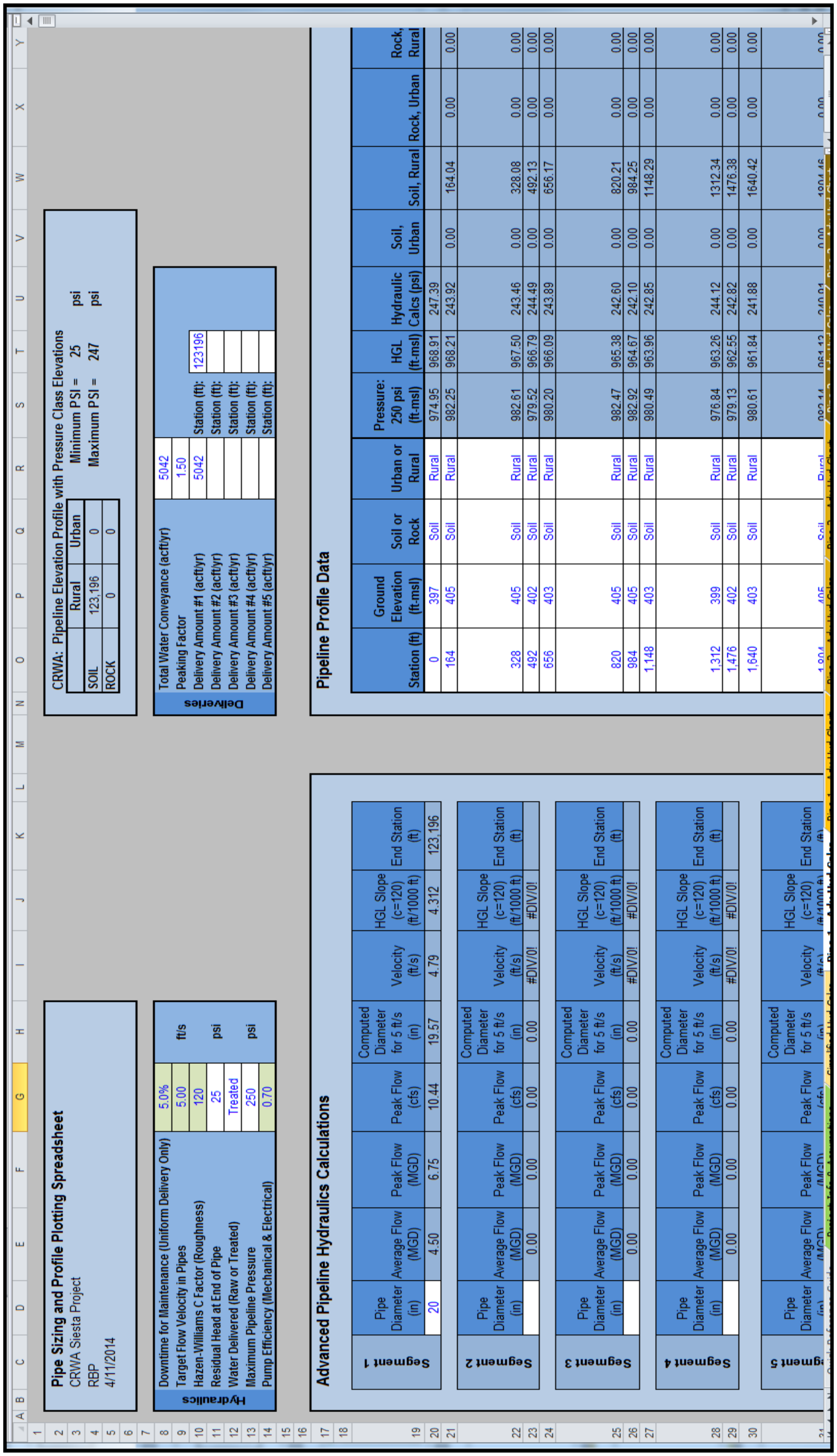


Figure 3. UCM Pipe Hydraulics (Advanced) Module



Pipe Sizing and Profile Plotting Spreadsheet
CRWA Siesta Project
RBP
4/11/2014

Hydraulics

Downtime for Maintenance (Uniform Delivery Only)	5.0%	
Target Flow Velocity in Pipes	5.00	ft/s
Hazen-Williams C Factor (Roughness)	120	
Residual Head at End of Pipe	25	psi
Water Delivered (Raw or Treated)	Treated	
Maximum Pipeline Pressure	250	psi
Pump Efficiency (Mechanical & Electrical)	0.70	

CRWA: Pipeline Elevation Profile with Pressure Class Elevations

	Rural	Urban
SOIL	123,196	0
ROCK	0	0

Minimum PSI = 25 psi
Maximum PSI = 247 psi

Deliveries

Total Water Conveyance (acft/yr)	5042		
Peaking Factor	1.50		
Delivery Amount #1 (acft/yr)	5042	Station (ft):	123196
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):	

Advanced Pipeline Hydraulics Calculations

Segment	Pipe Diameter (in)	Average Flow (MGD)	Peak Flow (MGD)	Peak Flow (cfs)	Computed Diameter for 5 ft/s (in)	Velocity (ft/s)	HGL Slope (c=120) (ft/1000 ft)	End Station (ft)
Segment 1	20	4.50	6.75	10.44	19.57	4.79	4.312	123,196
Segment 2		0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	
Segment 3		0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	
Segment 4		0.00	0.00	0.00	0.00	#DIV/0!	#DIV/0!	
Segment 5								

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	397	Soil	Rural	974.95	968.91	247.39				
164	405	Soil	Rural	982.25	968.21	243.92	0.00	164.04	0.00	0.00
328	405	Soil	Rural	982.61	967.50	243.46	0.00	328.08	0.00	0.00
492	402	Soil	Rural	979.52	966.79	244.49	0.00	492.13	0.00	0.00
656	403	Soil	Rural	980.20	966.09	243.89	0.00	656.17	0.00	0.00
820	405	Soil	Rural	982.47	965.38	242.60	0.00	820.21	0.00	0.00
984	405	Soil	Rural	982.92	964.67	242.10	0.00	984.25	0.00	0.00
1,148	403	Soil	Rural	980.49	963.96	242.85	0.00	1148.29	0.00	0.00
1,312	399	Soil	Rural	976.84	963.26	244.12	0.00	1312.34	0.00	0.00
1,476	402	Soil	Rural	979.13	962.55	242.82	0.00	1476.38	0.00	0.00
1,640	403	Soil	Rural	980.61	961.84	241.88	0.00	1640.42	0.00	0.00

Figure 4. Example UCM Pipe Hydraulics Plot

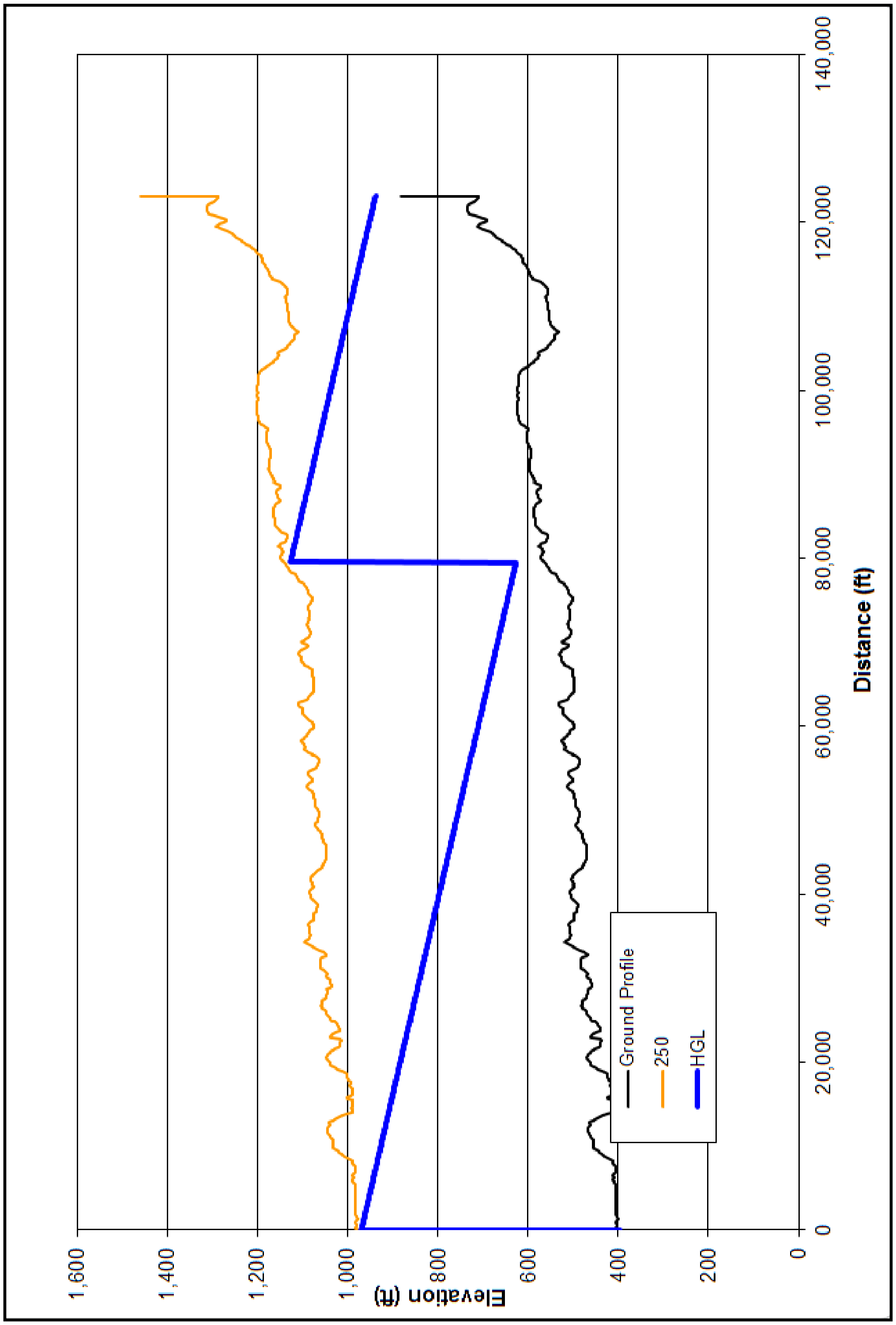


Figure 5. UCM Well Field Module

Well Field Calculations: Pipes and Pump Sizing

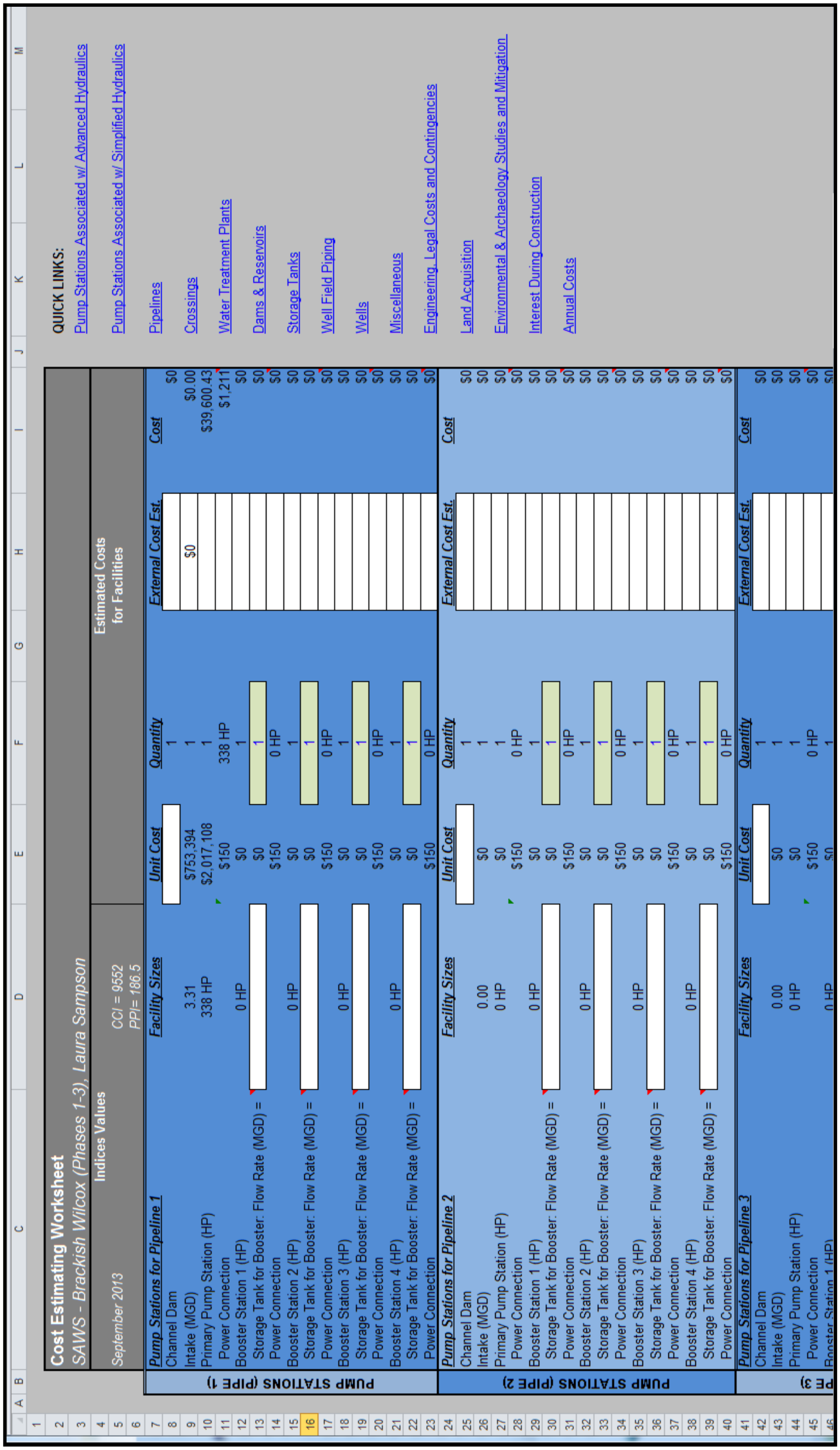
WUG/WWP: SAWS

Note: Be sure to enter well field piping information in the Costing Form module

Avg. Static Water El (ft-msl):	400	*Avg Flow Per Well (gpm):*	900
Drawdown:	190	*Peak Flow Per Well (gpm):*	900
Total Water Production (acft/yr):	14,485	*Avg Flow Per Well (cfs):*	2.07 cfs
Avg Well Field Yield (mgd):	12.92	*Peak Flow Per Well (cfs):*	2.07 cfs
Peaking Factor:	1	*Active Wells:*	10
Well Station Losses:	22	*Contingency Wells (15%):*	2
Elevation of Delivery Point (ft-msl):	560	*% Operating Time:*	0.831
C Factor:	120	*Minimum Pipeline Pressure (psi):*	15

	Well / Pipe Number	Flow (gpm)	Peak Flow (cfs)	Computed Diameter for 5 fps (in)	Selected Diameter (in)	Velocity (fps)	Length (ft)	Begin Elevation	DS Well/ Pipe Node	Begin Elevation in DS Well/Pipe (ft)	Elevation Delta	TDH (ft)	HP	Kw-hr	HGL Slope (ft/100ft) (c = 120)	Segment Pipe Head Loss
Well Field	4	700	1.61	7.68	8	4.61	4,040	520.00	3	570.00	50.00	98	22	121,079	11.76	47.50
	3	1,500	3.45	11.25	12	4.39	3,700	570.00	2	530.00	-40.00	0	0	0	6.69	24.74
	2	2,200	5.06	13.62	14	4.73	3,500	530.00	1	530.00	0.00	22	16	87,548	6.41	22.43
	1	700	1.61	7.68	8	4.61	1,200	530.00	1-11	550.00	20.00	34	8	42,357	11.76	14.11
	1-11	2,900	6.67	15.64	18	3.77	6,600	550.00	11	550.00	0.00	21	20	106,689	3.14	20.74
	11	3,700	8.51	17.67	18	4.82	1,800	550.00	12-10	560.00	10.00	19	23	123,899	4.93	8.88
	12	800	1.84	8.21	8	5.27	3,100	530.00	12-10	560.00	30.00	77	20	108,803	15.05	46.67
	12-10	4,500	10.35	19.48	18	5.86	1,200	560.00	10-9	550.00	-10.00	0	0	0	7.08	8.50
	10	800	1.84	8.21	8	5.27	860	560.00	10-9	550.00	-10.00	3	1	4,181	15.05	12.95
	10-9	5,300	12.19	21.14	24	3.88	2,800	550.00	9-J	560.00	10.00	17	29	156,198	2.36	6.61
	9-J	6,100	14.03	22.68	24	4.47	2,700	560.00	J	570.00	10.00	18	36	197,716	3.06	8.27
	5	900	2.07	8.71	8	5.93	5,000	560.00	6-7	590.00	30.00	124	36	197,325	18.72	93.59
	6	800	1.84	8.21	8	5.27	2,200	560.00	6-7	590.00	30.00	63	16	89,575	15.05	33.12
	8	1,000	2.30	9.18	12	2.93	3,100	550.00	7	580.00	30.00	40	13	70,584	3.16	9.79
	7	2,000	4.60	12.99	12	5.86	1,700	580.00	7-J	560.00	-20.00	0	0	0	11.38	19.35
	6-7	1,700	3.91	11.97	12	4.98	3,800	590.00	7-J	560.00	-30.00	2	1	6,104	8.43	32.02
	7-J	3,700	8.51	17.67	18	4.82	4,105	560.00	J	570.00	10.00	30	37	198,507	4.93	20.24
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
			0.00	0.00				0.00		0.00	0.00					
Trunkline		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
		0	0.00	0.00				0.00		0.00	0.00					
TOTALS							51,405						278	1,510,565		
	flow check (wells x gpm)	9,000														

Figure 6. UCM Detailed Costing Form Module



Cost Estimating Worksheet
SAWS - Brackish Wilcox (Phases 1-3), Laura Sampson

Indices Values		Estimated Costs for Facilities
September 2013	CCI = 9552 PPI= 186.5	

Pump Stations for Pipeline 1	Facility Sizes	Unit Cost	Quantity	External Cost Est.	Cost
Channel Dam			1		$0
Intake (MGD)	3.31	$753,394	1	$0	$0.00
Primary Pump Station (HP)	338 HP	$2,017,108	1		$39,600.43
Power Connection		$150	338 HP		$1,211
Booster Station 1 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 2 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 3 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 4 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0

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		$150	0 HP		$0
Booster Station 1 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 2 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 3 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0
Booster Station 4 (HP)	0 HP	$0	1		$0
Storage Tank for Booster: Flow Rate (MGD) =		$0	1		$0
Power Connection		$150	0 HP		$0

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		$150	0 HP		$0
Booster Station 1 (HP)	0 HP	$0	1		$0

QUICK LINKS:
- Pump Stations Associated w/ Advanced Hydraulics
- Pump Stations Associated w/ Simplified Hydraulics
- Pipelines
- Crossings
- Water Treatment Plants
- Dams & Reservoirs
- Storage Tanks
- Well Field Piping
- Wells
- Miscellaneous
- Engineering, Legal Costs and Contingencies
- Land Acquisition
- Environmental & Archaeology Studies and Mitigation
- Interest During Construction
- Annual Costs

Figure 7. UCM Cost Summary Output Table

Item	Estimated Costs for Facilities
Cost Estimate Summary	
Water Supply Project Option	
41518 Prices	
New Braunfels - 5 MGD WTP/ASR project	
Cost based on ENR CCI 9552 for 41518 and	
a PPI of 187 for 41518	
CAPITAL COST	
Well Fields (Wells, Pumps, and Piping)	$3,805,000
Storage Tanks (Other Than at Booster Pump Stations)	$0
Two Water Treatment Plants (2.5 MGD and 2.2 MGD)	$7,247,000
Integration, Relocations, & Other	$108,000
TOTAL COST OF FACILITIES	**$11,160,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$3,906,000
Environmental & Archaeology Studies and Mitigation	$5,000
Land Acquisition and Surveying	$0
Interest During Construction (4% for 1 years with a 1% ROI)	$528,000
TOTAL COST OF PROJECT	**$15,599,000**
ANNUAL COST	
Debt Service (5.5 percent, 20 years)	$1,305,000
Reservoir Debt Service (5.5 percent, 40 years)	$0
Operation and Maintenance	
Intake, Pipeline, Pump Station (1% of Cost of Facilities)	$38,000
Dam and Reservoir (1.5% of Cost of Facilities)	$0
Water Treatment Plant (2.5% of Cost of Facilities)	$784,000
Pumping Energy ($/kwhr)	$37,000
Purchase of Water (acft/yr @ $/acft)	$0
TOTAL ANNUAL COST	**$2,164,000**
Available Project Yield (acft/yr), based on a Peaking Factor of 1	3,700
Annual Cost of Water ($ per acft)	$585
Annual Cost of Water ($ per 1,000 gallons)	$1.79

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