WATER UTILITY

MASTER PLAN

February 2025

AIM NORMAN
AREA & INFRASTRUCTURE MASTER PLAN

WATER UTILITY MASTER PLAN
DRAFT

CITY OF NORMAN AND NORMAN UTILITIES AUTHORITY

NORMAN, OKLAHOMA

AIM NORMAN
AREA & INFRASTRUCTURE MASTER PLAN

Prepared by:

GARVER

In Partnership with:

RDG PLANNING • DESIGN

DRAFT
February 2025

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I hereby certify that this Water Utility Master Plan for the City of Norman Area & Infrastructure Master Plan was prepared by Garver under my direct supervision for the City of Norman and Norman Utilities Authority.

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LIST OF ACRONYMS

Acronym	Definition
µg/L	micrograms per liter
AACE	Association for the Advancement of Cost Engineering
ADD	average day demand
AFY	acre feet per year
AIM	Area and Infrastructure Master
AOP	advanced oxidation process
AWWA	American Water Works Association
BAF	biologically active filtration
BOR	Bureau of Reclamation
CIP	capital improvement plan
COMCD	Central Oklahoma Master Conservancy District
DPR	direct potable reuse
EST	elevated storage tank
GIS	geographic information system
gpcd	gallons per capita per day
gpd	gallons per day
GST	ground storage tank
HAA5	five regulated haloacetic acids
HDPE	high density polyethylene
HPP	high pressure plane
IFC	International Fire Code
IPR	indirect potable reuse
LCR	Lead and Copper Rule
LCRI	Lead and Copper Rule Improvements
LF	linear foot
MCL	maximum contaminant level
MDD	max day demand
mg/L	milligrams per liter
MG	million gallons
MGD	million gallons per day
MPP	main pressure plane
NUA	Norman Utilities Authority
OCWUT	Oklahoma City Water Utilities Trust
ODEQ	Oklahoma Department of Environmental Quality
OKC	Oklahoma City
OPCC	opinion of probable construction costs
OWRB	Oklahoma Water Resource Board
psi	pounds per square inch
RO	reverse osmosis
SCADA	supervisory control and data acquisition
SFE	single-family equivalent
TTHM	total trihalomethanes
UV	ultraviolet
WRF	water reclamation facility
WSA	water service area
WTP	water treatment plant

INTRODUCTION TO AIM NORMAN

In 2023, the City of Norman embarked on an ambitious endeavor: The Norman Area & Infrastructure Master Plan (AIM Norman). Decisions made in Norman today and in the years to come will shape city's growth, development patterns, and the community image for decades. Rapidly changing and evolving technology, extreme weather events, and the University of Oklahoma's growing national audience as a new member of the Southeastern Conference will all impact these decisions.

AIM Norman examines all elements of city development and quality of life to help shape the community's growth through 2045. Together, all seven Master Plans of AIM Norman provide a roadmap that will provide essential guidance to leaders and decision-makers, representing the City and its partners' plan for growth, change, and adaptation.

AIM Norman is:

- A combination of processes and Master Plans.
- A blueprint for a sustainable and resilient future that embraces Norman's unique character.
- A collective vision for Norman that should resonate with every community member.
- All-encompassing and inclusive, supported by every facet of the community, and align with the values and aspirations of Norman residents.

AIM Norman encompasses distinct master planning elements, with the Land Use Plan as the guide for development and land use policy to help inform all Master Plans.

HOUSING

A safe, comfortable, and attainable home for all is critical to Norman's future success. Rising home prices contribute to housing challenges. The recognition of poverty and unhoused populations in Norman is growing, while limited student housing options strain existing neighborhoods. The increasing popularity of the Oklahoma City metro as a place to live creates more demand, coupled with long-time residents wanting to age in the community. The AIM Norman Housing Plan analyzes the housing market and outlines a strategic plan for addressing housing needs.

STORMWATER

Major rain events impact Norman's residents and infrastructure. The City has recently shifted away from the traditional system of hard, channelized drainage paths and concentration of stormwater flows toward more sustainable stormwater policies. However, challenges remain, including flooding, erosion, and pollution of streams flowing into Lake Thunderbird. As growth and development increase impervious surface coverage, the City must accommodate stormwater effectively throughout the community. The AIM Norman 2025 Stormwater Master Plan Update outlines resilient solutions to help Norman's stormwater management systems adapt to both current and future challenges.

TRANSPORTATION

Mobility routes create a more connected community when it feels safe, comfortable, and accessible for all users. As the Norman community grows geographically and in population, so too must the routes and options to get to places. Car-centric communities like Norman are considering a more multi-modal approach to transportation. People are looking for connected trails and safe bike routes when choosing where to live, as new personal transportation devices grant more people opportunities to leverage trails. The AIM Norman Comprehensive Transportation Plan Update identifies future mobility projects in existing and new neighborhoods for motorists and active transportation users to cast a positive vision for mobility in Norman.

PARKS, RECREATION, AND CULTURE

Along with a comprehensive trail network, residents value cities with unique quality of life amenities — particularly parks, recreational opportunities, and special events. Norman has more parks per capita than many comparable cities. Maintaining these parks at a first-class level is a high priority that grows in difficulty as costs rise and resources decline. Residents desire a connection to nature and each other, along with vibrant cultural and community events and facilities for all ages and abilities. The AIM Norman Parks, Recreation, and Culture Master Plan aims to provide current and future residents with safe and engaging parks, recreation, events, and cultural activities to access and enjoy.

WASTEWATER

Reliable and resilient wastewater service is vital for existing and future homes, businesses, and industries. As more users are added and the wastewater collection system is expanded, adequate treatment facilities for quantity and quality must also be in place to meet environmental standards and water quality requirements. The AIM Wastewater Master Plan analyzes wastewater capacity needs and identifies improvements to the collection and treatment of wastewater to meet current and future needs in accordance with environmental regulations while minimizing costs to ratepayers.

WATER

Access to quality water supply is critical for existing and future homes, businesses, and industries. Currently, Norman's critical water supply comes from Lake Thunderbird, the Garber-Wellington Aquifer, and wholesale water purchases from Oklahoma City. With projected residential and commercial growth, future constraints on the water supply and infrastructure are expected and must be addressed. The AIM Norman Water Master Plan analyzes the water system's capacity and water supply needs and identifies improvements to meet existing and future demands.

INTEGRATING THE AIM NORMAN MASTER PLANS

A thoughtful, coordinated approach ensures that all seven elements of AIM Norman work together to create a balanced, sustainable, and thriving community for current and future residents. Together, they shape how Norman looks, feels, and functions. Major decisions in one component influence the others and determine the trajectory of land use development.

DEVELOPMENT PRINCIPLES

The AIM Norman Land Use Plan's Development Principles stem from Norman residents' input and Smart Growth for America's Principles of Smart Growth. The ten Development Principles align AIM Norman's plans and studies to guide Norman's evolution through 2045.

AIM NORMAN DEVELOPMENT PRINCIPLES

1. **Manage urban services efficiently.**
2. **Promote diverse housing options.**
3. **Promote infill development and neighborhood reinvestment.**
4. **Protect the environment in all decision-making.**
5. **Enhance distinctive neighborhoods, business districts, and natural areas with a strong sense of place.**
6. **Provide a multi-modal and connected transportation network.**
7. **Enhance public safety and minimize hazards.**
8. **Encourage balanced and connected neighborhoods.**
9. **Make development decisions predictable, fair, and cost effective.**
10. **Make decisions in a transparent and collaborative manner.**

WATER UTILITY MASTER PLAN EXECUTIVE SUMMARY

As part of the Norman Area and Infrastructure Master Plan (AIM) project, the City of Norman (City) and Norman Utilities Authority (NUA) are updating their Master Plans for both the water supply and distribution system. This Water Utility Master Plan (Master Plan) provides a comprehensive evaluation of the distribution system and a hydraulic model update, as well as a review and update to the existing water supply plan (previously completed by others in 2014).

The main goals of the plan are to:

- **Evaluate Current Infrastructure:** Review and evaluate the existing water system to identify opportunities for improvement.
- **Predict Future Needs:** Analyze factors like population growth to forecast future water demand.
- **Plan Upgrades:** Suggest improvements to the water supply and distribution system to meet future needs and regulations.
- **Promote Sustainability:** Use sustainable practices to conserve water and protect the environment.
- **Increase Resilience:** Enhance the system's ability to handle emergencies and recover from disasters.

NUA tasked RDG and Garver to produce a Master Plan for the water supply and water distribution system. This Master Plan presents water projections, evaluates the water distribution system's existing and future performance, discusses supply challenges, and outlines a Capital Improvement Plan (CIP) to address system challenges and support system growth.

The NUA water system serves the urban area within the municipal boundary of the City with over 600 miles of underground water lines and water storage facilities throughout the City. The current water service area (WSA) generally extends from 48th Avenue West to 36th Avenue East, shown below in Map ES-1. Approximately 90% of the City's populations lives within the water service boundary.

NUA utilizes three main sources of water: surface water, groundwater, and water purchased from a neighboring utility (Oklahoma City). Since 2000, NUA has had the ability to buy treated water from Oklahoma City (OKC) via a connection in the northernmost part of the WSA. In 2015, NUA entered into an agreement with the Oklahoma City Water Utilities Trust (OCWUT) to regularly buy treated water based on a subscribed monthly capacity reservation of approximately one million gallons per day (MGD).

Most of NUA's supply is obtained through surface water from Lake Thunderbird, which is treated at the Vernon Campbell Water Treatment Plant (WTP). NUA currently has an annual water rights allocation of 3,084 MG of supply from Lake Thunderbird. However, when the lake's water elevation is in the flood pool. NUA has the opportunity of withdraw that "flood pool" water as additional supply supplementary to the normal water right allocation. In recent years, NUA has utilized flood pool water to meet demands. The remaining demand is met by 43 groundwater wells in the Garber-Wellington Aquifer underlying the City. Figure ES-1 summarizes the annual water supply by source between 2003 and 2023.

Map ES-1: Water System Overview

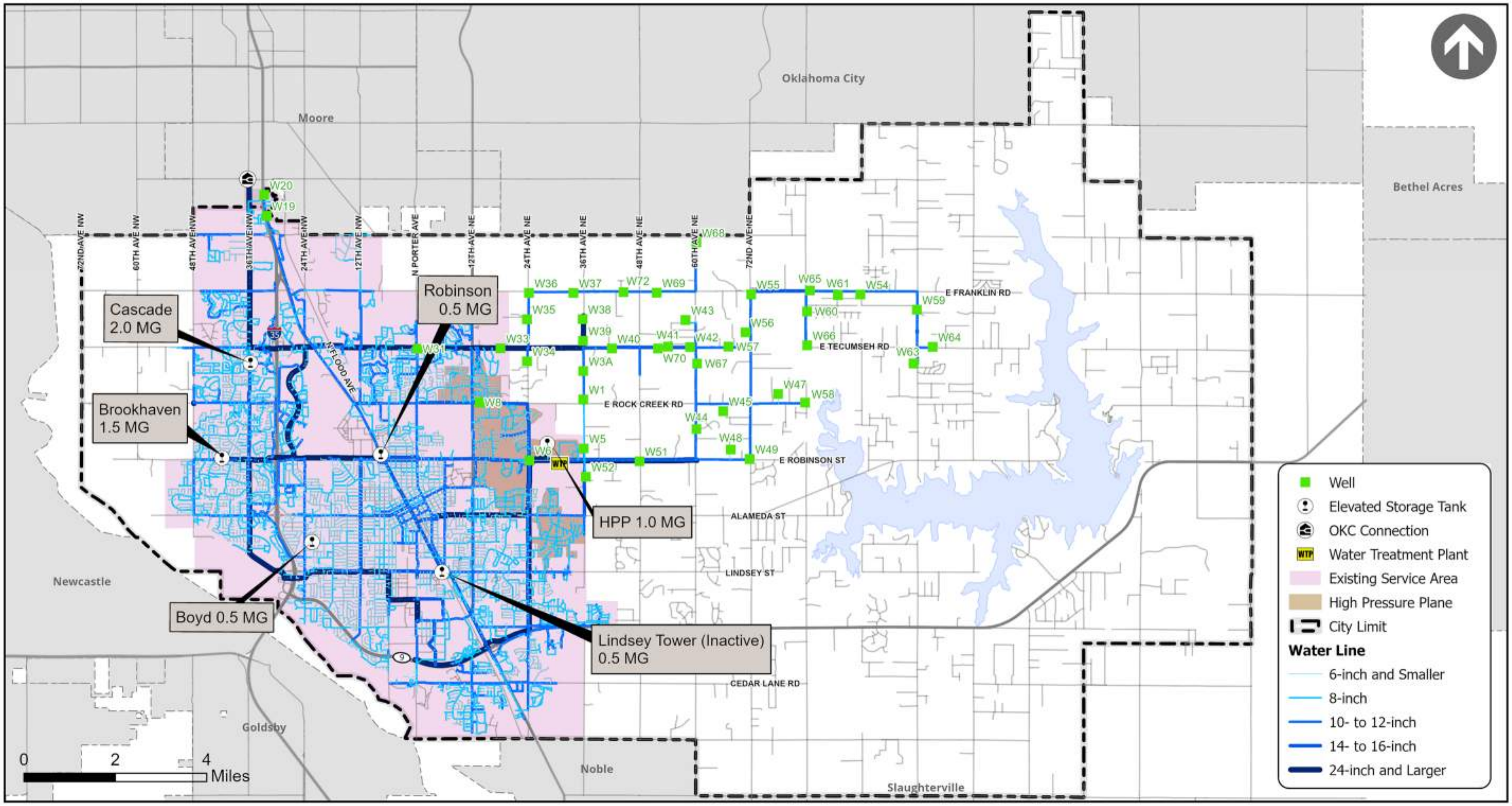
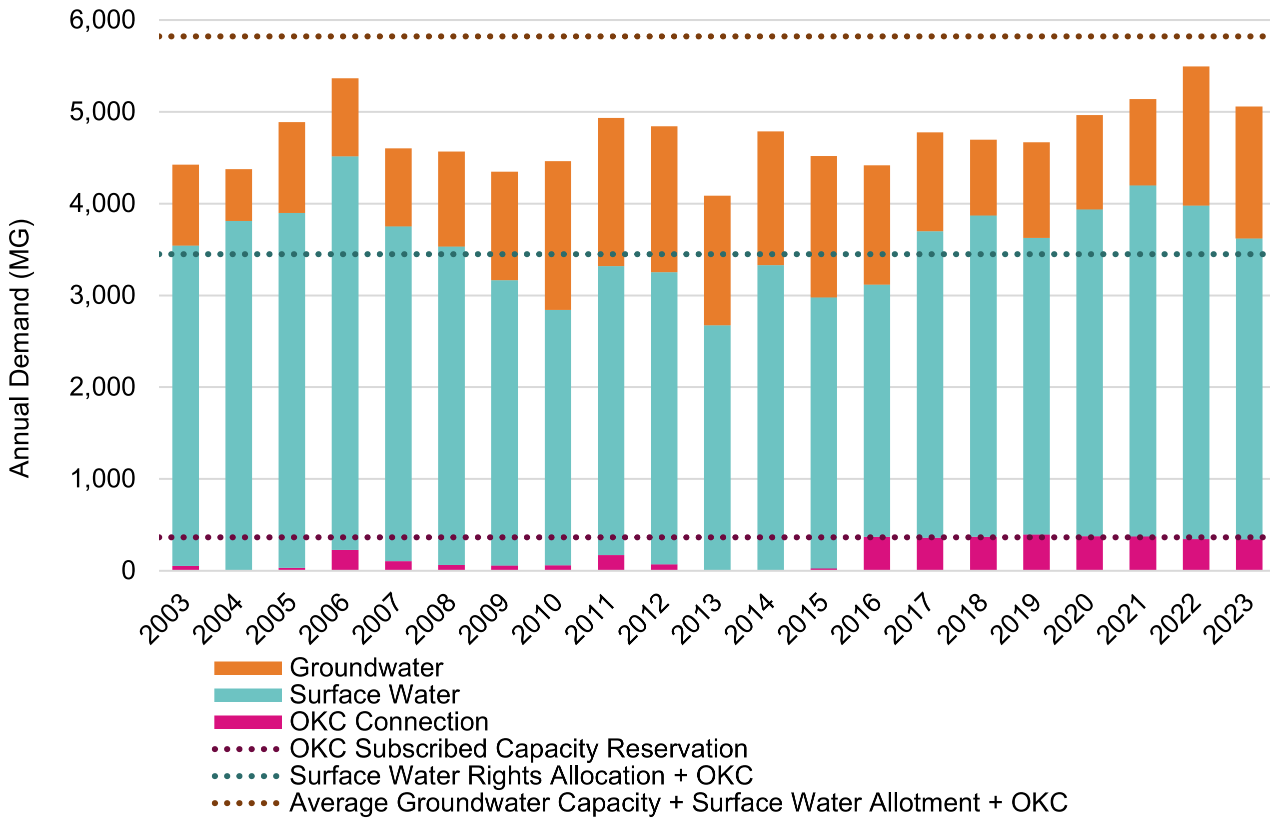


Figure ES-1: Annual Water Production by Source



The historical service population was used to determine the average day demand (ADD) and max day demand (MDD) per capita values, which are 136 gpcd and 250 gpcd, respectively. Production data from 1990-2022 was provided, but only data after 2008 was considered to better capture current usage for ADD and MDD per capita demands. Additionally, a 10% reserve capacity was included for both ADD and MDD projections to align with the 2060 Water Supply Plan. This reserve helps mitigate potential demand changes due to new large users, unexpected growth, or severe droughts. The projected ADD and MDD are shown in Table ES-1.

Garver determined that the ADD per capita was approximately 136 gpcd. The value was derived comparing ADD data over the noted period. An additional 10% (14 gpcd) was applied to account for reserve capacity for a total ADD per capita demand of 150 gpcd. This value is within the range of 144 to 160 gpcd used in the 2060 Water Supply Plan.

The projected MDD was derived using the MDD over the past 15 years, which correlated to a value of 250 gpcd. An additional 10% (25 gpcd) was added to account for reserve capacity for a total MDD of 275 gpcd. This value is within the range of 274 to 304 gpcd used in the 2060 Water Supply Plan.

Table ES-1: Projected Water Demands

Year	Service Population	ADD (MGD)	ADD Reserve Capacity (MGD)	ADD Total (MGD)	MDD (MGD)	MDD Reserve Capacity (MGD)	MDD Total (MGD)
2025	123,865	16.8	1.7	18.5	31.0	3.1	34.1
2030	133,155	18.1	1.8	19.9	33.3	3.3	36.6
2035	143,142	19.5	1.9	21.4	35.8	3.6	39.4

Year	Service Population	ADD (MGD)	ADD Reserve Capacity (MGD)	ADD Total (MGD)	MDD (MGD)	MDD Reserve Capacity (MGD)	MDD Total (MGD)
2040	153,877	20.9	2.1	23.0	38.5	3.8	42.3
2045	165,418	22.5	2.2	24.7	41.4	4.1	45.5

Figure ES-2 and Figure ES-3 show the historical consumption and the projected ADD and MDD through 2045. Projections through the year 2045 were used for CIP development. The projections through 2060 were based off the land use capacity of the service area and were used to determine sizing.

Figure ES-2: Historical and Projected Average Day

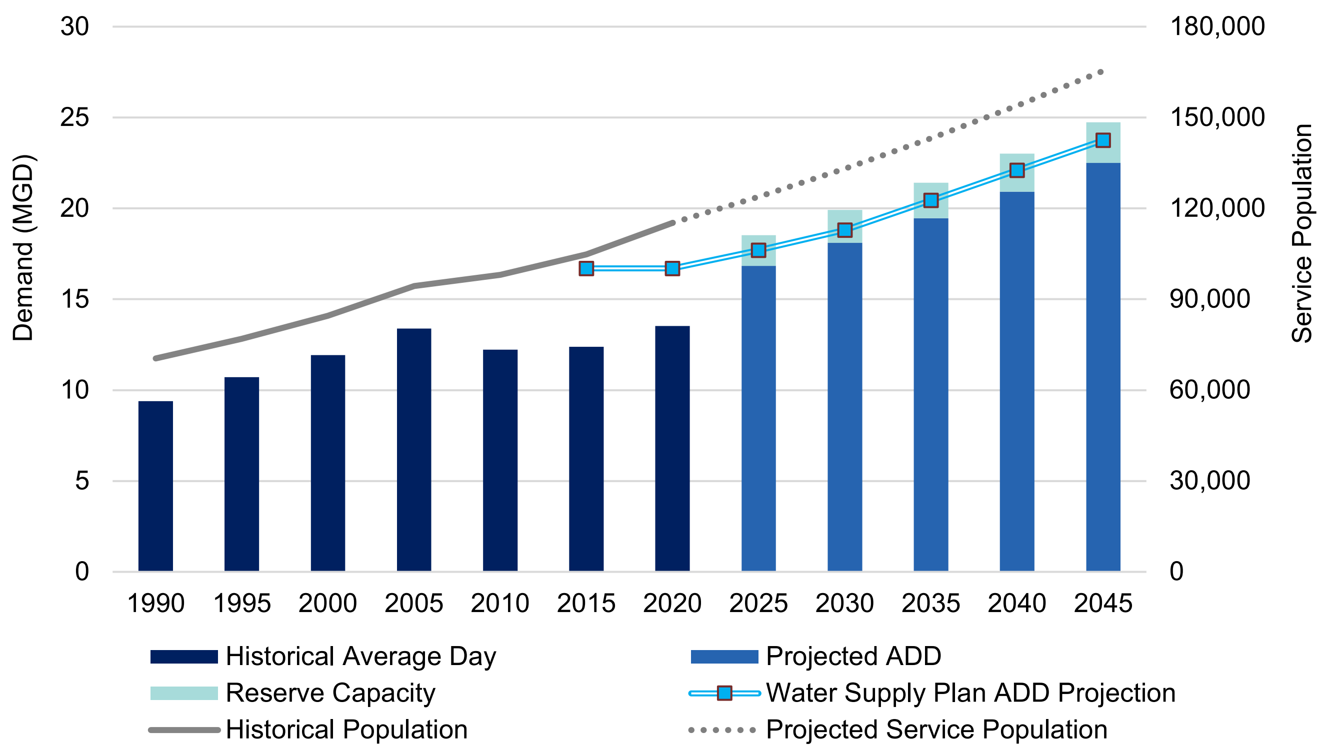
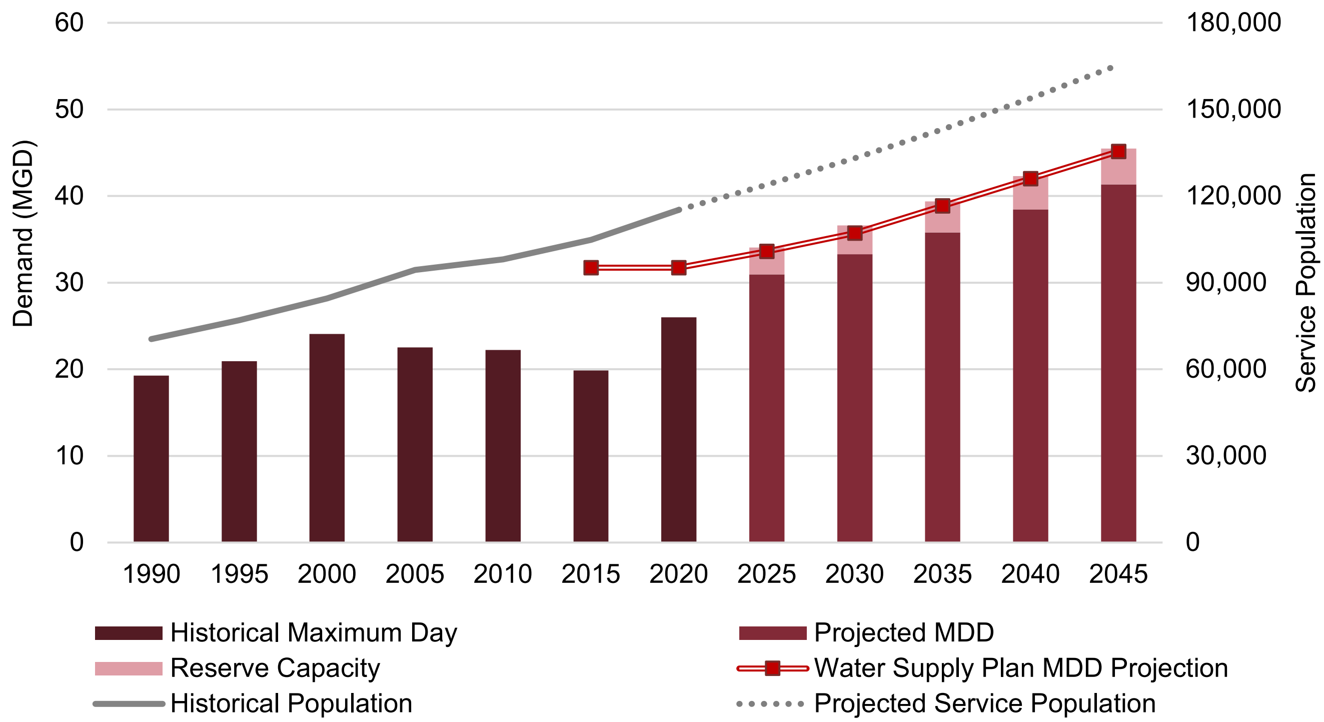


Figure ES-3: Historical and Projected Max Day Demand



As previously discussed, NUA uses three main sources for water supply: surface water, groundwater, and purchased water from OKC. The permitted amounts, or the average and maximum capacities of each source, are summarized in Table ES-2.

Table ES-2: Supply Capacity Summary

Source	Average Annual Capacity (MGD)	Maximum Day Capacity (MGD)
OKC	1.0	1.0
Groundwater	6.5	12.0
Surface Water	8.5	17.0
Total	16.0	30.0

Figure ES-4 and Figure ES-5 compare the projected ADD and MDD to the current capacities of each source between 2025 to 2045. Without the availability of flood pool supply from Lake Thunderbird, NUA would be unable to supply the projected ADD (excluding the reserve capacity) with the current sources of supply by around 2030. Similarly, NUA may be unable to supply MDD (excluding the reserve capacity) during hot and dry summer conditions without new sources of supply or watering restrictions by 2025.

Figure ES-4: Projected Average Day Demand Supply Gap Analysis

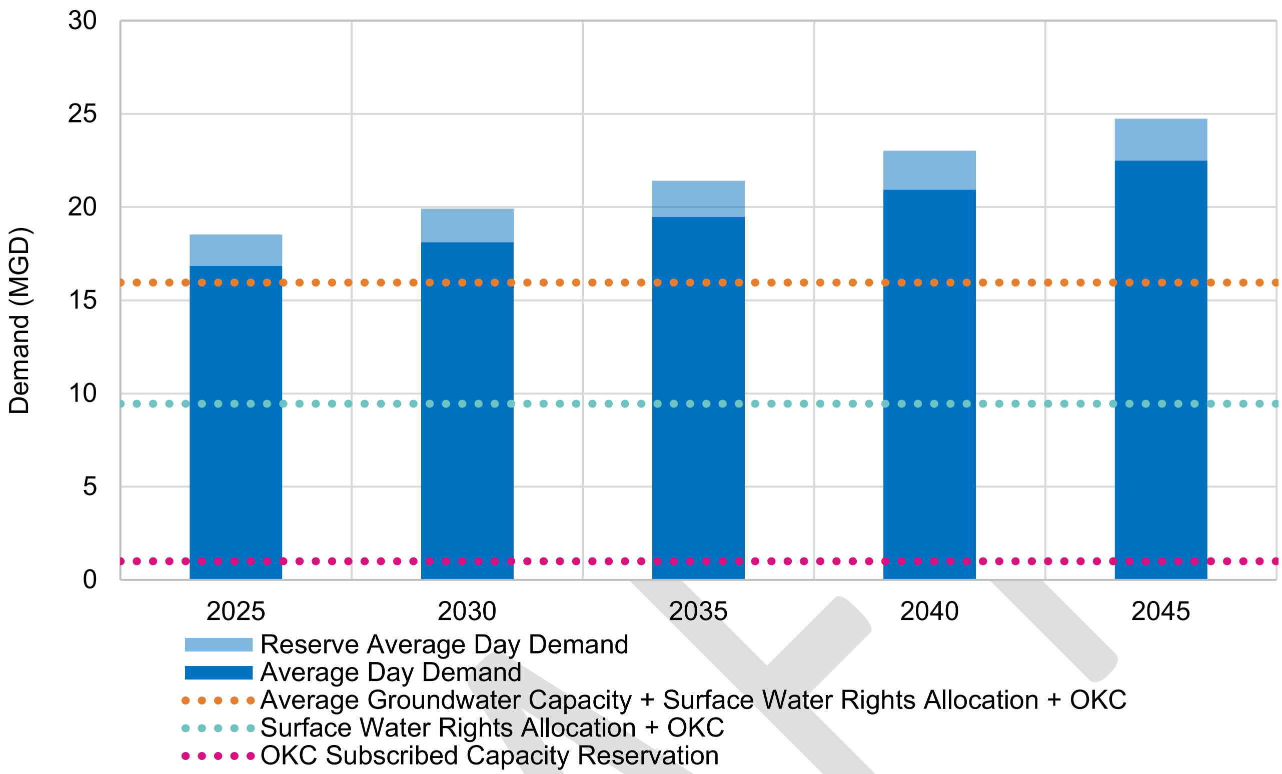
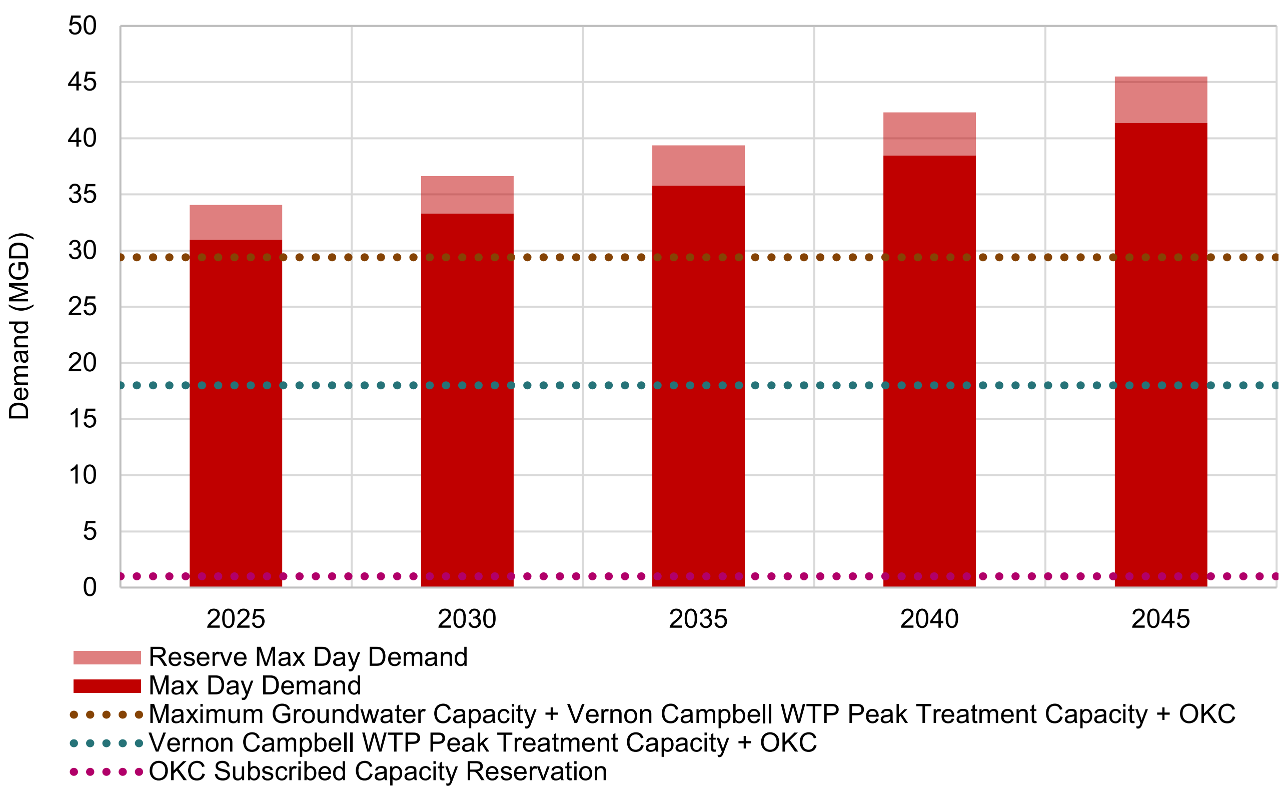


Figure ES-5: Projected Maximum Day Demand Supply Gap Analysis



Garver re-evaluated the potential water supply sources outlined in the 2060 Water Supply Plan. Since the 2014 publication date, multiple water supply sources that were presented in the report have since been deemed non-viable for various reasons. In contrast, new source alternatives have since become available, and additional source alternatives were added. The potential supplies currently under consideration are the following:

- Lake Thunderbird
- Garber-Wellington Groundwater Wells
- Purchased Finished Water from OKC
- Indirect Potable Reuse (IPR) via Lake Thunderbird Augmentation
- Direct Potable Reuse (DPR)
- New Out-of-Basin Reservoir (Parker or Scissortail)
- New In-Basin Reservoir
- South Canadian River Alluvial Wells

Along with the re-evaluation of the potential sources, Garver also updated the non-monetary criteria used for source selection. The use of non-monetary criteria allows NUA's priorities to be accurately reflected during the selection process rather than project cost being the main driver when selecting alternatives.

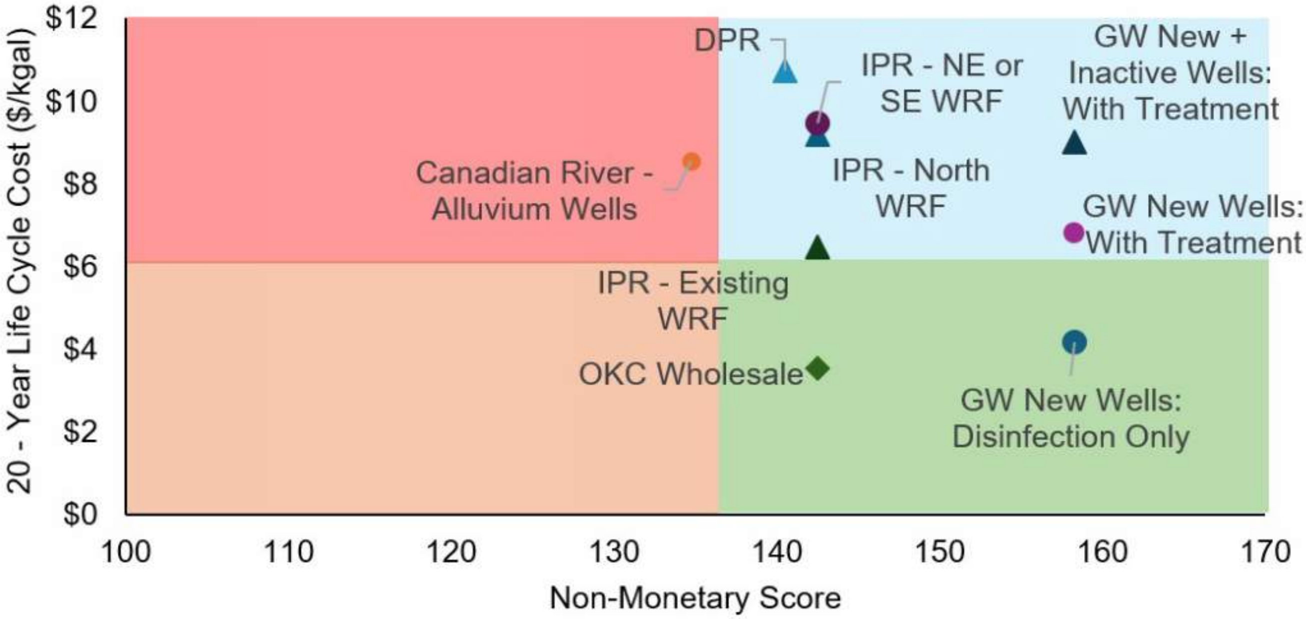
A non-monetary scoring exercise was completed during a meeting attended by the AIM Norman Water and Wastewater Sub-Committee, NUA Staff, and Garver. The overall rankings for each scoring group are presented in Table ES-3. Across all three scoring groups, the new groundwater wells scored the highest, while alluvial wells, and a new out-of-basin reservoir scored the lowest among all three groups.

Table ES-3: Non-Monetary Score Rankings

Scoring Group	Ranking					
	First	Second	Third	Fourth	Fifth	Sixth
AIM Norman Sub-Committee	Groundwater Wells	IPR	OKC	DPR	Alluvial Wells	New Reservoir
NUA Staff	Groundwater Wells	OKC	IPR	DPR	Alluvial Wells	New Reservoir
Garver	Groundwater Wells	IPR	OKC	DPR	Alluvial Wells	New Reservoir

To compare all alternatives, non-monetary scores and each alternative’s anticipated costs were plotted on a matrix. This heat map was created to visualize and compare all alternatives. The heat map showing non-monetary scores and 20-year life cycle costs is presented in Figure ES-6.

Figure ES-6: Non-Monetary Score vs. 20-Year Life Cycle Cost



The results of the non-monetary and monetary scoring were used to select the final supply alternatives, which include the following:

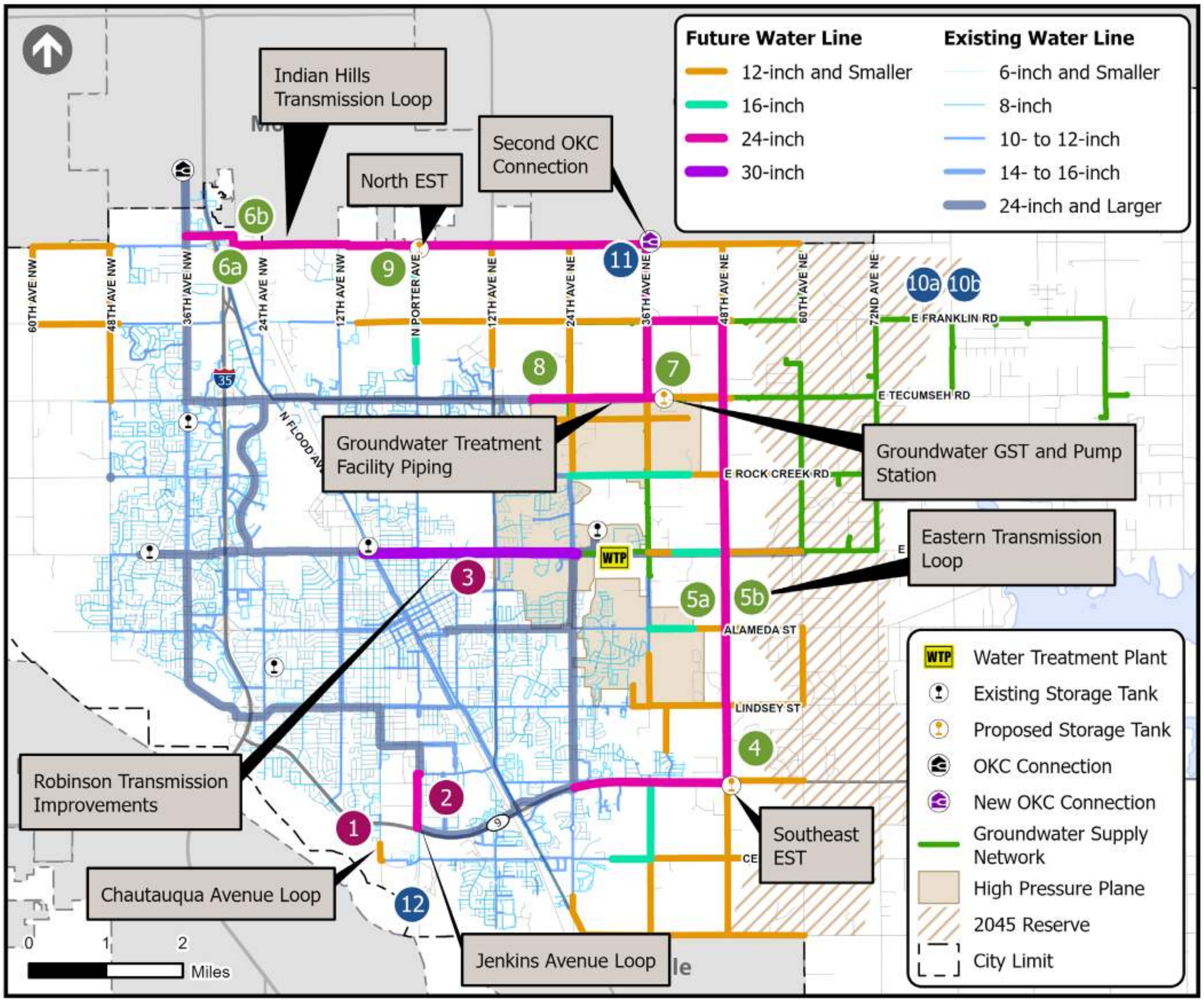
- NUA uses purchased water from OKC to meet an immediate increase in demands. Once the daily average volume needed exceeds 6 MGD, a second OKC connection will be necessary.
- New Garber-Wellington groundwater wells can also be constructed to minimize supply gaps.
- To meet the anticipated long-term supply gaps, it is recommended that either (indirect potable reuse) IPR or (direct potable reuse) DPR be constructed. This phased approach will allow NUA to phase in new sources as necessary as demands increase.

Most future growth is expected in the northern and eastern portions of the WSA. Additional water supply capacity is anticipated from new groundwater wells, wholesale water purchased from OKC, and water reuse. To better convey the anticipated flows from these sources and improve existing system deficiencies a series of Capital Improvement Plan (CIP) projects were identified. Garver identified several projects as part of a 20-year CIP with the intent of increasing supply, storage, and transmission capacity to accommodate future growth over the next 20 years. The locations of the 20-year CIP projects are shown in Map ES-2, and individual costs are presented in Table ES-4.

Table ES-4: 20-Year CIP Cost Summary

Project Number	Existing WSA Improvements	Anticipated Date of Project	Estimated Project Cost (2024 Dollars)
1	Chautauqua Loop: 12-inch	2025	$0.7M
2	Jenkins Loop: 24-inch	2026	$4.0M
3	Robinson Transmission Main: 30-inch	2030	$19.5M
		Existing WSA Improvements Subtotal	**$24.2M**
Project Number	**Future WSA Improvements**	**Anticipated Date of Project**	**Estimated Project Cost (2024 Dollars)**
4	Southeast Elevated Storage Tank (EST)	2027	$15.3M
5a, 5b	Eastern Transmission Loop: 24-inch	2027 & 2035	$51.4M
6a, 6b	Indian Hills Transmission Loop: 24-inch	2028 & 2033	$45.8M
7	GW Treatment Ground Storage Tank (GST) & Pump Station	2032	$15.3M
8	GW Treatment Facility Piping to System: 24-inch	2032	$9.6M
9	North EST	2038	$15.3M
		Future WSA Improvements Subtotal	**$152.7M**
Project Number	**Supply Improvements**	**Anticipated Date of Project**	**Estimated Project Cost (2024 Dollars)**
10a, 10b	New Garber-Wellington Wells	2029 & 2036	$65.5M
11	Second OKC Connection	2033	$23.3M
12	Reuse Water Supply System	2034	$350.0M
		Supply Improvements Subtotal	**$438.8M**
		Improvements Total	**$615.7M**

Map ES-2: 20-Year CIP Projects



1.0 INTRODUCTION

As part of the Norman Area and Infrastructure Master Plan (AIM) project, the City of Norman (City) and Norman Utilities Authority (NUA) are updating their Master Plans for both the water supply and distribution system. This Water Utility Master Plan (Master Plan) provides a comprehensive evaluation of the distribution system and a hydraulic model update, as well as a review and update to the existing water supply plan (previously completed by others in 2014).

The primary objectives of this Master Plan are to:

- Assess Current Infrastructure: Review and evaluate the existing system to identify opportunities for improvement.
- Forecast Future Demand: Analyze population growth, economic development, and other factors to predict future water needs.
- Develop Strategic Improvements: Propose targeted upgrades and expansions to the water supply and distribution system network to meet anticipated demand and regulatory requirements.
- Promote Sustainability: Incorporate sustainable practices and technologies to promote water conservation and environmental stewardship.
- Enhance Resilience: Strengthen the system's ability to withstand and recover from emergencies, including natural disasters and infrastructure failures.

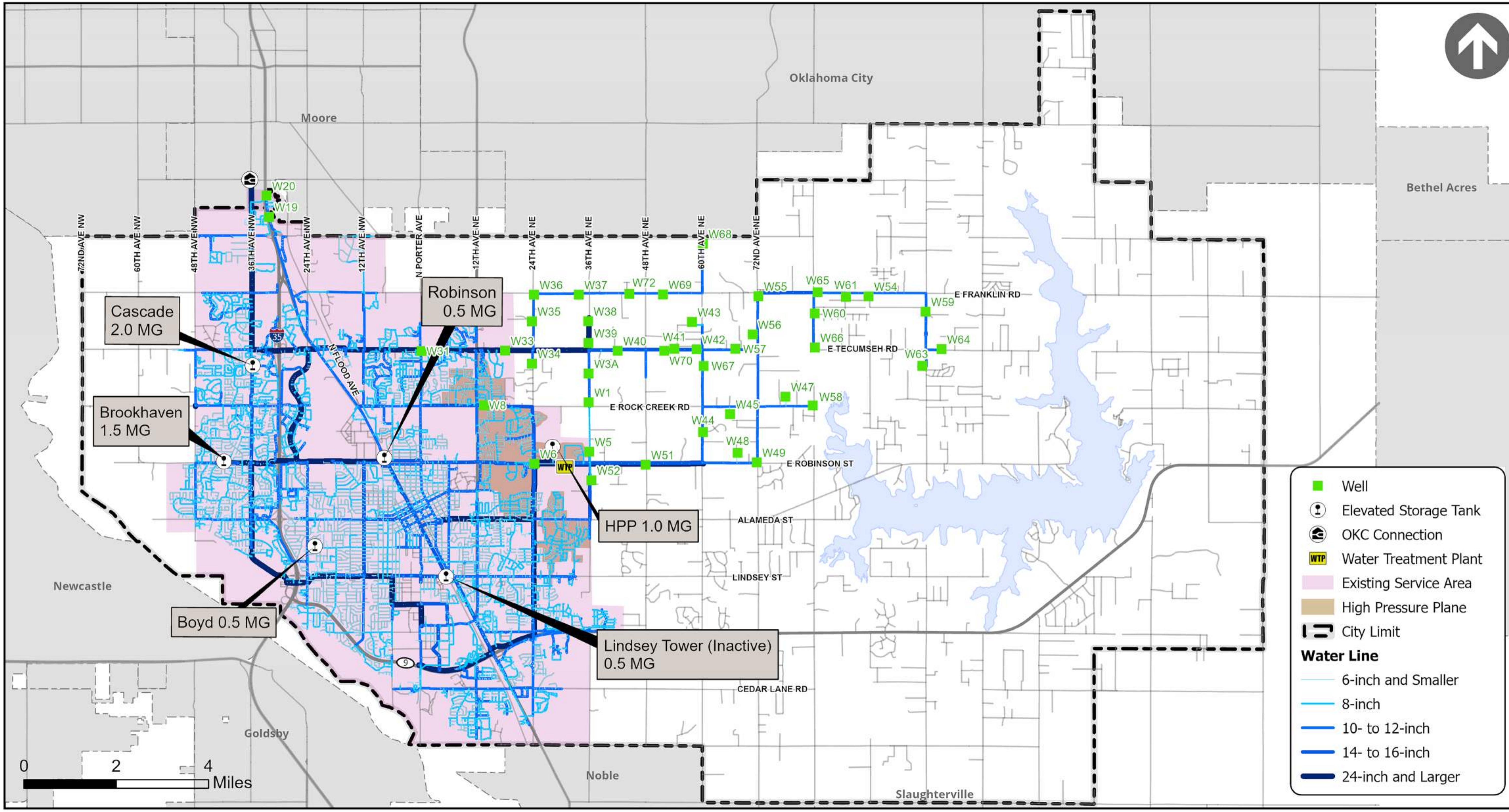
NUA tasked RDG and Garver to produce a Master Plan for the water supply and water distribution system. This Master Plan presents water projections, evaluates the water distribution system's existing and future performance, discusses supply challenges, and outlines a Capital Improvement Plan (CIP) to address system challenges and support system growth.

1.1 WATER SYSTEM OVERVIEW

The NUA water system serves the urban area within the municipal boundary. The water system includes three primary components:

- Sources of Supply: For this Master Plan, supply includes everything up to the point of entry into the distribution system. The NUA water system has three sources of supply:
    - Groundwater from the Garber-Wellington Aquifer supplied from 43 groundwater wells
    - Surface water from Lake Thunderbird
    - Wholesale treated water purchased from OKC
- Water Treatment: The Vernon Campbell Water Treatment Plant (WTP) that treats water from Lake Thunderbird
- Water Distribution System: The pipes and tanks that convey finished water to each customer

NUA's current water service area (WSA) generally extends from 48th Avenue West to 36th Avenue East as shown in Map 1-1. Approximately 90% of the City's population lives within the water service boundary.



Oklahoma City
Moore
Bethel Acres
Newcastle
Goldsby
Noble
Slaughterville
Cascade
2.0 MG
Robinson
0.5 MG
Brookhaven
1.5 MG
HPP 1.0 MG
Boyd 0.5 MG
Lindsey Tower (Inactive)
0.5 MG
72ND AVE NW
60TH AVE NW
48TH AVE NW
36TH AVE NW
24TH AVE NW
12TH AVE NW
N PORTER AVE
12TH AVE NE
24TH AVE NE
36TH AVE NE
48TH AVE NE
60TH AVE NE
72ND AVE NE
N FLOOD AVE
E FRANKLIN RD
E TECUMSEH RD
E ROCK CREEK RD
E ROBINSON ST
ALAMEDA ST
LINDSEY ST
CEDAR LANE RD
0 2 4
Miles
Well
Elevated Storage Tank
OKC Connection
Water Treatment Plant
Existing Service Area
High Pressure Plane
City Limit
Water Line
6-inch and Smaller
8-inch
10- to 12-inch
14- to 16-inch
24-inch and Larger

1.2 NORMAN UTILITIES AUTHORITY OPERATIONS AND MANAGEMENT

The NUA is a public trust that oversees policy and financial authorizations as they relate to City-managed utilities. The Mayor and City Council act as Trustees of the NUA. Three of the Norman Utilities Department Divisions administer and operate the water utility: Administration & Engineering, Water Treatment, and Line Maintenance. The Utilities Department has adopted the following Mission Statement:

Providing environmentally sound, efficient utility service to our customers in a professional, safe manner at sustainable rates through six divisions.

1.3 RELATED DOCUMENTS

Table 1-1 summarizes the earlier work by others that was used in this Master Plan. The reference names listed in the table are used throughout this report to refer to each document.

Table 1-1: Related Documents

Document	Author/Agency	Date	Reference Name
2060 Strategic Water Supply Plan	Carollo	2014	2060 Water Supply Plan
Update Distribution System Modeling	Alan Plummer Associates, Inc.	2018	2018 Modeling Update
AIM Norman Area & Infrastructure Master Plan - Norman Today	RDG	2024	Norman Today
AIM Norman Comprehensive Plan	RDG	2025	Norman Comprehensive Plan

1.4 HISTORICAL DATA COLLECTION

The following data was provided by NUA for the use in the development of this Master Plan:

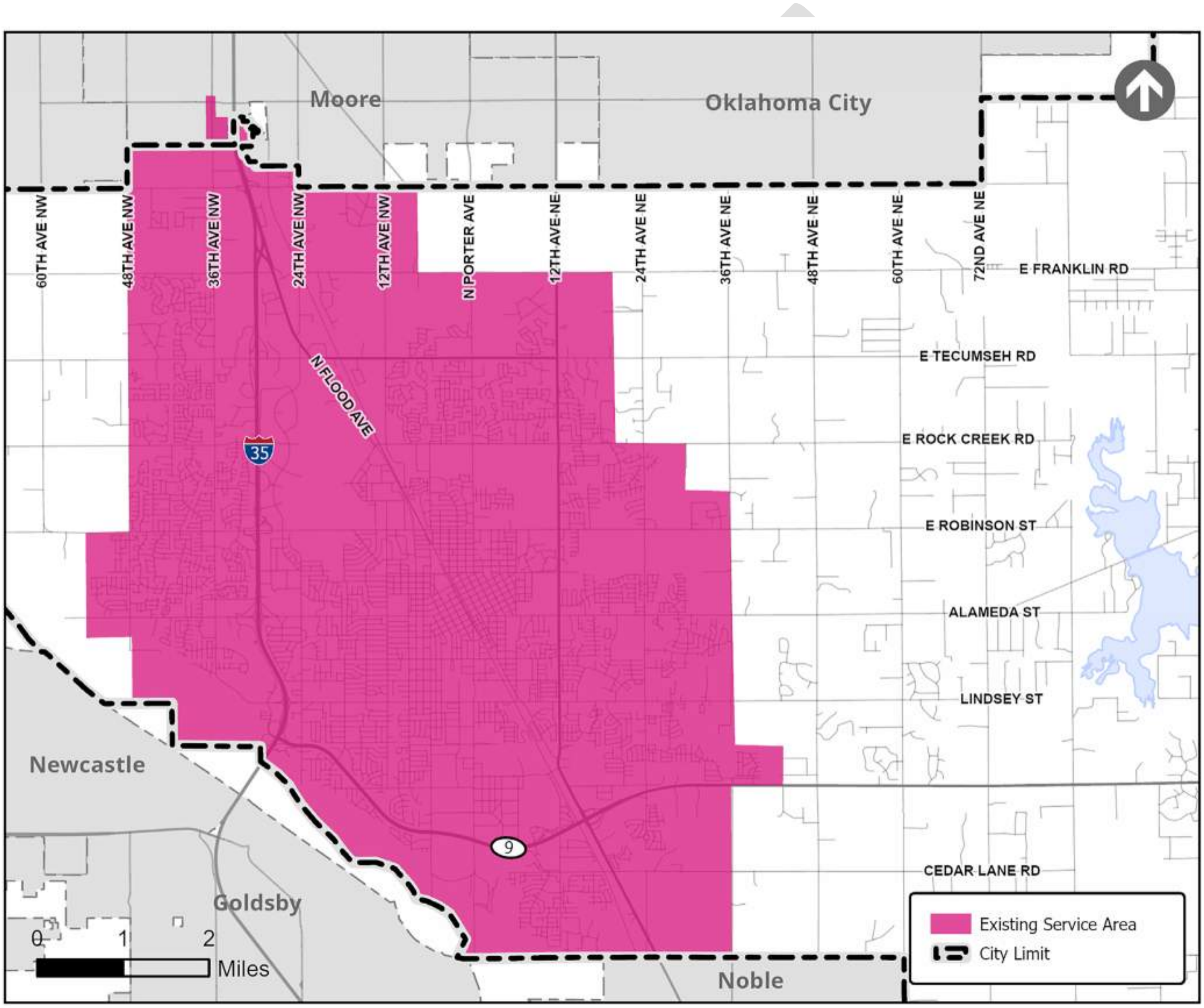
- Customer Meter Data (2019–2023)
- Water Production Data (1990–2023)
- Monthly Operating Reports (2014–2023)
- Water Audit Reports (2019–2023)
- Water Quality Data (2010–2023)
- Geographic information system (GIS) base files with water infrastructure information

2.0 WATER SERVICE AREA

2.1 EXISTING WATER SERVICE AREA

The existing NUA water distribution system serves the majority of residents. The NUA WSA is illustrated in Map 2-1. In general, the current WSA boundary extends from 48th Avenue West to 36th Avenue East, and was based on the existing infrastructure and existing land use derived from the Norman Today report which can be found in Appendix A.

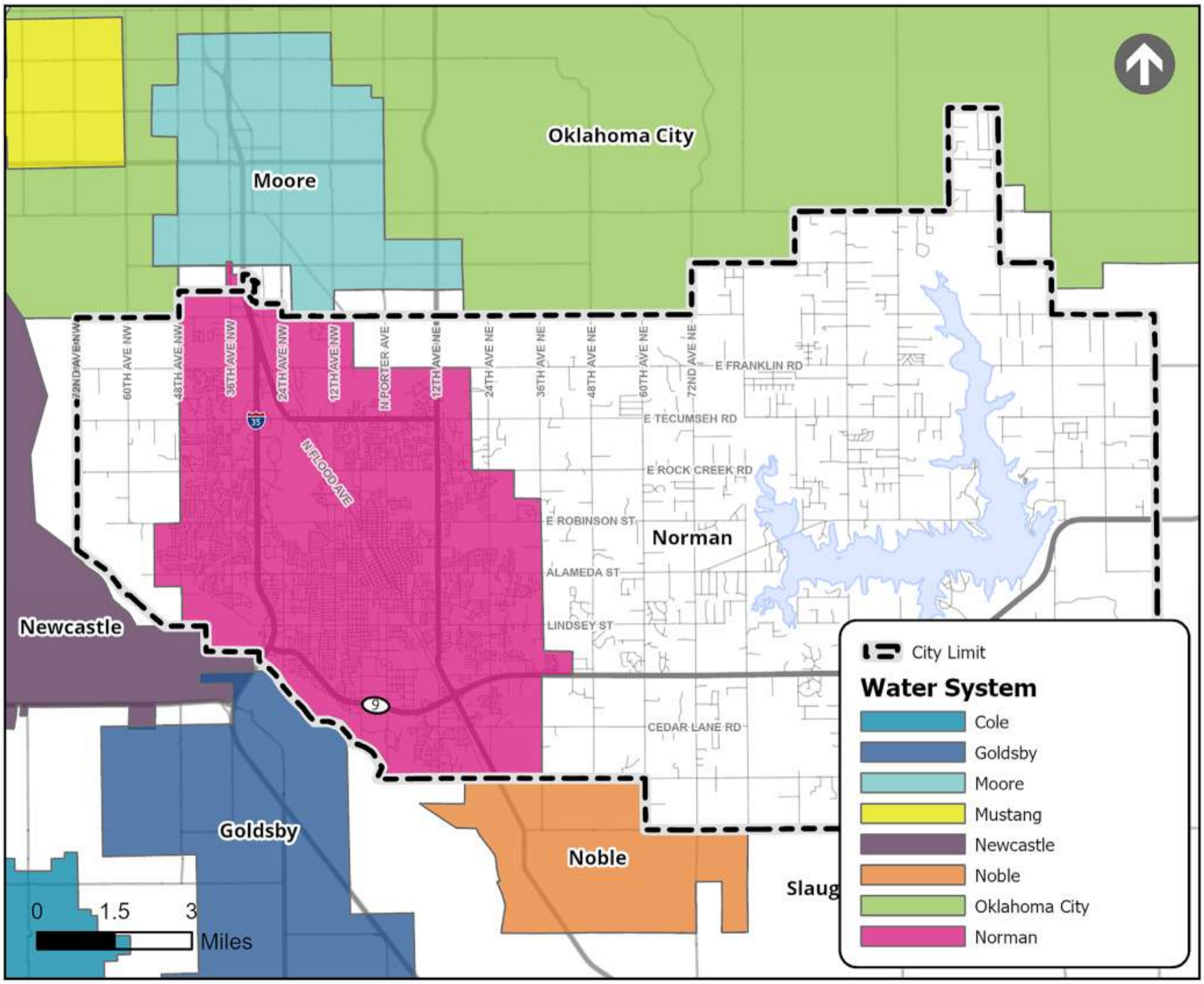
Map 2-1: Water Service Area Overview



2.1.1 ADJACENT WATER UTILITIES

The water utilities next to the NUA WSA are shown in Map 2-2.

Map 2-2: Adjacent Water Systems



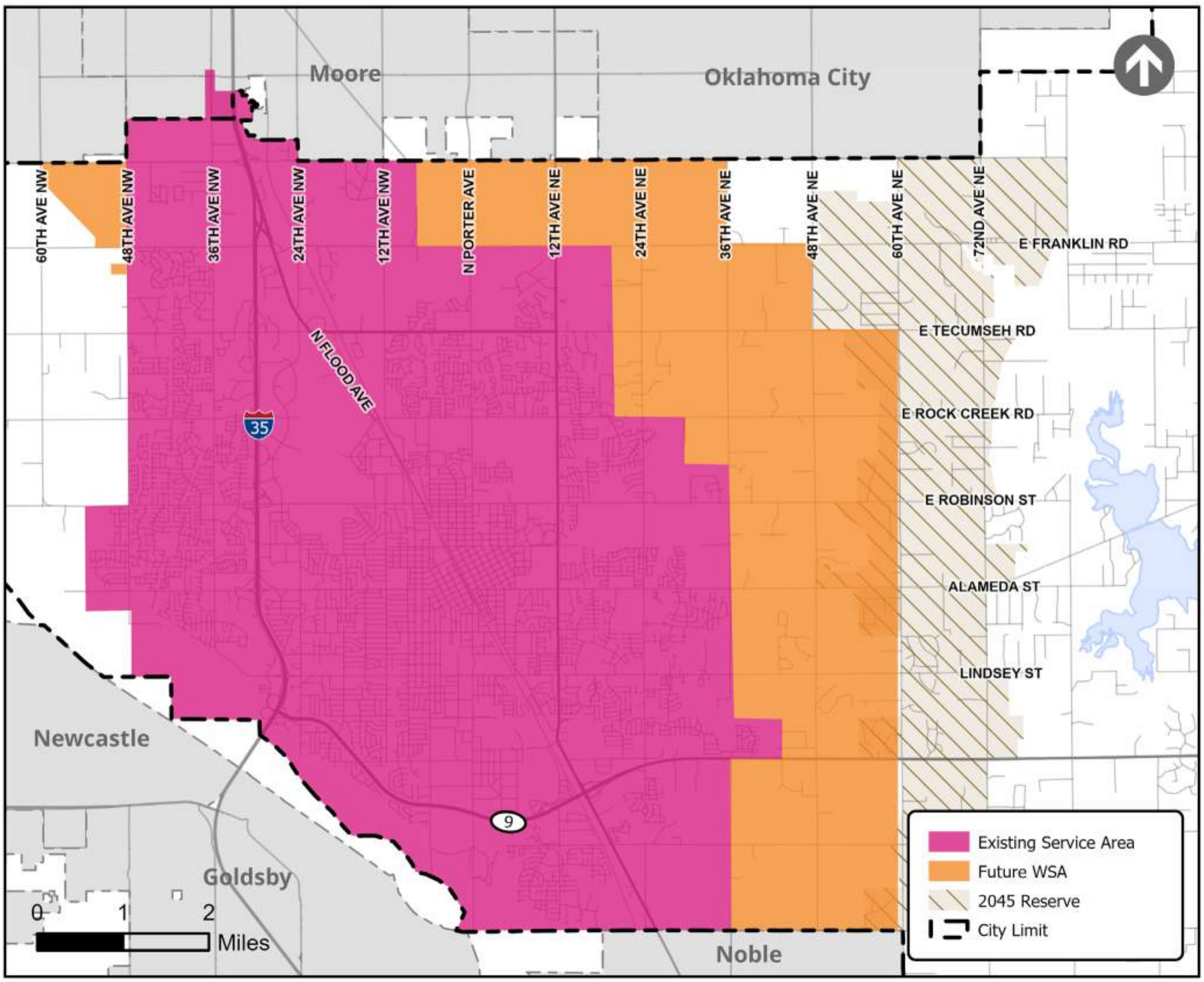
2.2 FUTURE WATER SERVICE AREA

Future land use was developed for the AIM Norman Comprehensive Plan and was used to estimate the anticipated future needs and necessary improvements to the distribution system. These areas and their anticipated land use classification are shown in Map 2-3. A more detailed future land use classification map is presented in Appendix B.

The Norman Comprehensive Plan shows a significant expansion of the existing WSA based on the future land use, as well as the associated increases in demand through 2045. Growth is not anticipated east of 60th Avenue East into the 2045 Reserve, nor is it anticipated west of 60th Avenue West, as shown in Map 2-3.

Additionally, there is a reserve area east of the anticipated future WSA, which the Comprehensive Plan describes as a sparsely developed area east of the existing WSA with mainly large-lot residential users. High-intensity urban development in this area is not expected due to access to existing infrastructure and challenges with water quality from runoff into the Lake Thunderbird watershed. However, development in this area may be considered when City services are available to adequately serve future users.

Map 2-3: Future Water Service Area



3.0 HISTORICAL POPULATION AND WATER DEMANDS

3.1 HISTORICAL WATER PRODUCTION

NUA uses three main water supplies: surface water, groundwater, and purchased water from a neighboring utility. Figure 3-1 summarizes the annual water supply by source between 2003 and 2023.

Since 2000, NUA has had the ability to purchase treated water from OKC via a connection in the northernmost part of the WSA. In 2015, NUA entered into an agreement with the Oklahoma City Water Utilities Trust (OCWUT) to regularly purchase treated water based on a subscribed monthly capacity reservation of approximately 1 MGD.

Most of NUA's supply is taken from the surface water of Lake Thunderbird. The NUA currently has an annual water rights allocation of 3,084 MG of supply from Lake Thunderbird. However, when the lake's water elevation is in the flood pool, NUA can utilize temporary water rights to consume water in the flood pool that is not counted towards their annual allocation. In recent years, NUA has relied on flood pool water to meet demands, as shown in Figure 3-2. The remaining demand is met by groundwater from the Garber-Wellington Aquifer underlying the City via 43 groundwater wells. Further discussion related to existing water supply challenges is discussed in Section 13.2.

Figure 3-1: Annual Water Production by Source

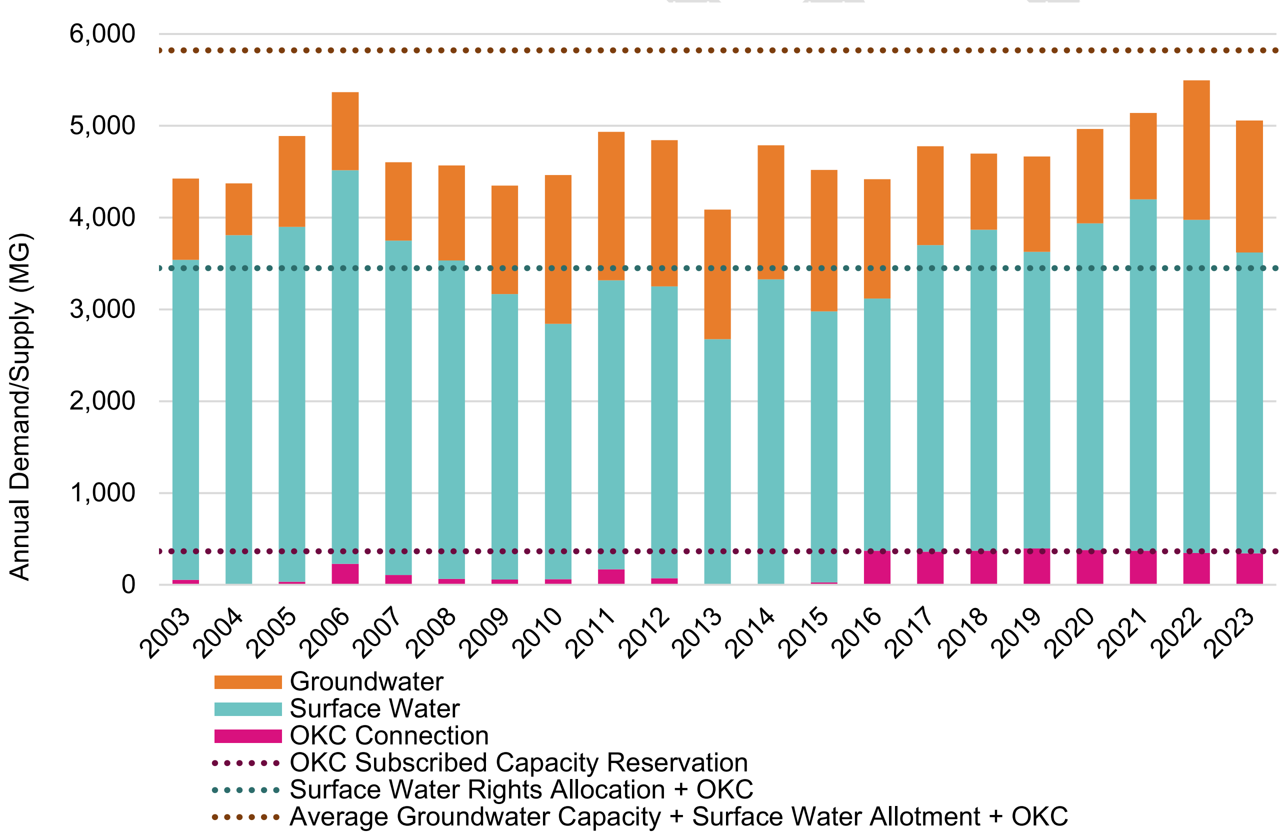
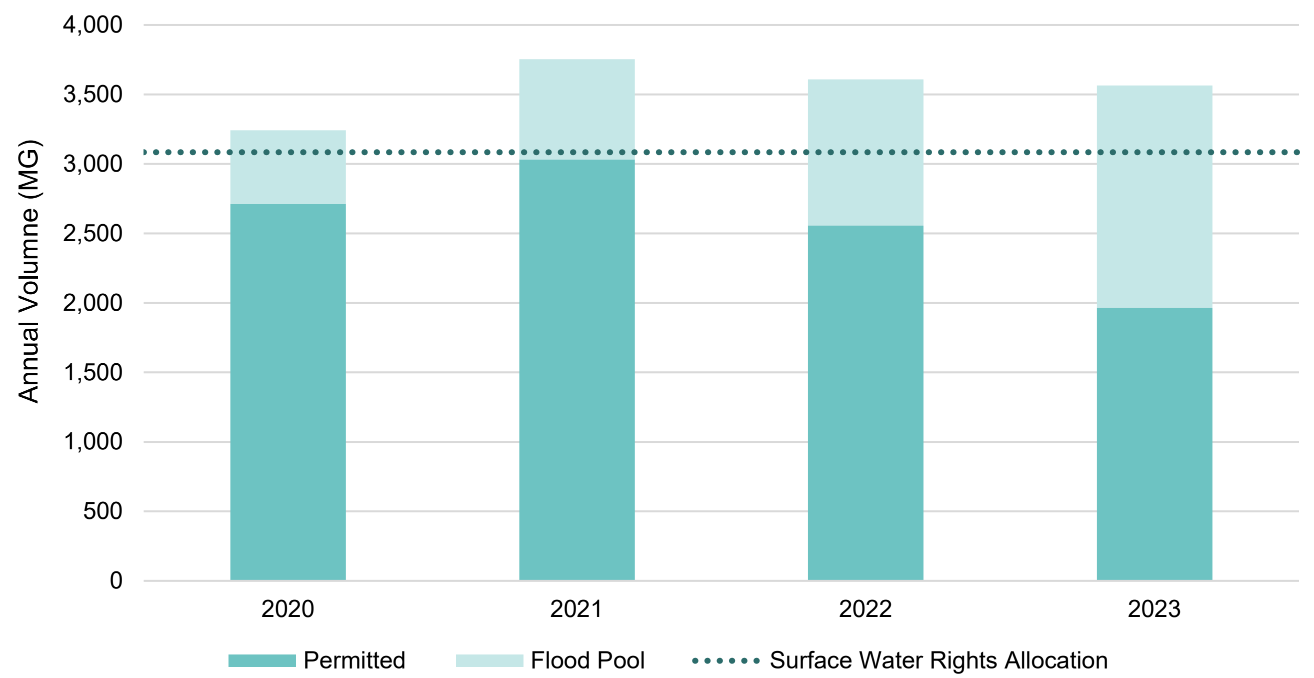


Figure 3-2: Surface Water Allotment and Usage



3.2 HISTORICAL POPULATION GROWTH

Historical population data for both the City and Cleveland County were obtained from the U.S. Census Bureau and are shown in Table 3-1.

Table 3-1: U.S. Census Population Data

Year	Cleveland County Population	City of Norman Population
1990	174,253	80,071
2000	208,016	95,693
2010	255,755	110,925
2020	295,528	128,026

NUA provided historical service population data between 1990 and 2023, and a summary of the data in five-year intervals is shown in Table 3-2. As of 2022, NUA served a population of approximately 113,553 customers via approximately 42,600 meters. Historically, the service population has been approximately 88% of the total city population. The 2060 Water Supply Plan estimated that the NUA service population would be about 90% of the total city population by 2025, and this assumption was used for determining the future service population discussed in Section 4.1.

Table 3-2: Historical Water Service Population Data

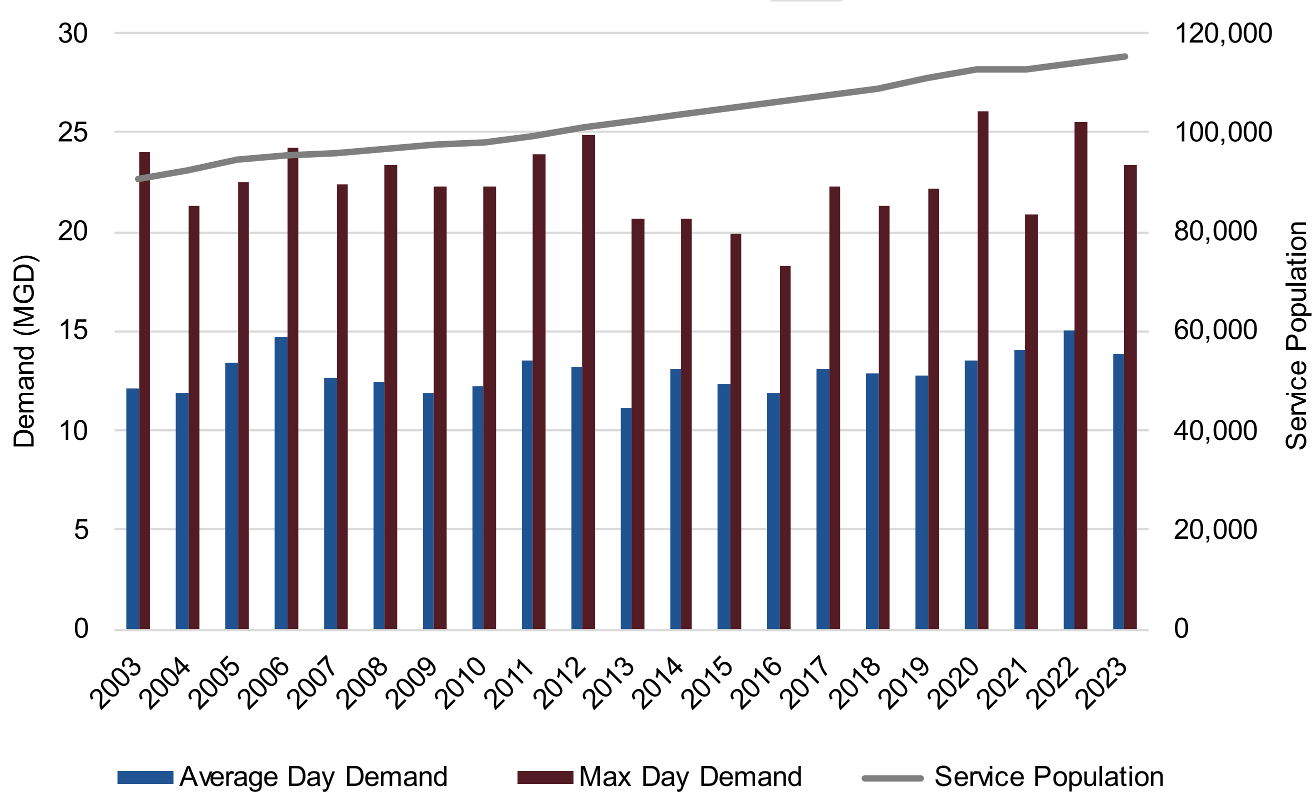
Year	Service Population	Percent of City of Norman Population
1990	70,462	88.0%
1995	76,987	87.8%
2000	84,538	88.3%
2005	94,398	91.0%
2010	98,075	88.4%
2015	104,843	87.7%

2020	112,151	88.0%

3.3 HISTORICAL WATER DEMAND

The NUA provided historical production data between 1990 and 2023. The historical average day demand (ADD) and maximum day demand (MDD), as well as the service population estimates, are shown in Figure 3-3. The figure indicates that the population growth over the last 20 years has been approximately linear. However, both the ADD and MDD fluctuated over the period. The ADD experienced more variability over the 20-year time period but generally increases over time. Local maxima within the MDD data set often correlate to known drought/dry years (2006, 2012, and 2020).

Figure 3-3: Historical Daily Water Demand and Service Population

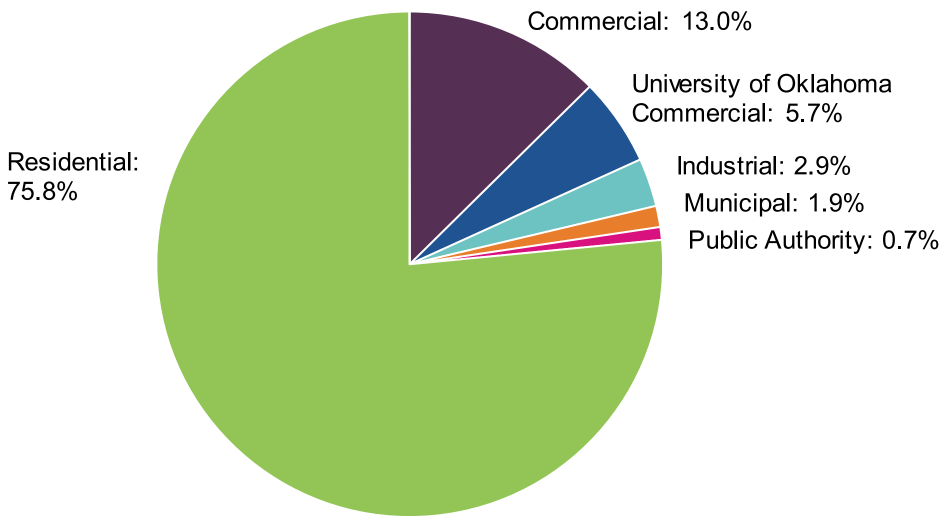


3.4 HISTORICAL CUSTOMER BILLING DATA

Garver categorized consumption into six separate user classes: residential, commercial, University of Oklahoma commercial, industrial, municipal, and public authority from historical billing data from 2021 and 2022. Figure 3-4 illustrates the percent of the total metered consumption by user class. Residential water usage accounts for the highest portion of billed volume at 75.8% of the annual water consumption. The commercial, University of Oklahoma commercial, and industrial account for approximately 13.0%, 5.7%, and 2.9% of the annual water consumption, respectively.

Water production exceeds billed consumption, as not all water produced flows through customer meters. Historical water production and billed consumption data were used to determine that the ratio of the ADD to average day consumption has typically been approximately 1.25. This ratio was used for the purposes of adjusting data derived from historical metered consumption to a realistic demand value (Section 3.6 and Section 3.7). Water loss is discussed in more detail in Section 3.8.

Figure 3-4: Percent Consumption by User Class



3.5 PER CAPITA WATER DEMANDS

Garver evaluated per capita demands using historical service population data and historical water demand data to understand ADD and MDD trends. Figure 3-5 and Figure 3-6 illustrate the per capita demand for ADD and MDD conditions between 2002 and 2022, respectively. The per capita MDD has been steadily decreasing since 2002, while per capita ADD has marginally decreased since 2002.

Garver determined that the ADD per capita was around 136 gpcd. The value was derived comparing maximum ADD data over the noted period. An additional 10% (14 gpcd) was applied to account for reserve capacity for a total ADD per capita demand of 150 gpcd. This value is within the range of 144 to 160 gpcd used in the 2060 Water Supply Plan. Per capita demand varied in the 2060 Water Supply Plan projection due to the inclusion of passive conservation savings.

The projected MDD was derived using the MDD over the past 15 years, which correlated to a value of 250 gpcd. An additional 10% (25 gpcd) was added to account for reserve capacity for a total MDD of 275 gpcd. This value is within the range of 274 to 304 gpcd used in the 2060 Water Supply Plan. The 2060 Water Supply Plan values were derived by applying the maximum historical peaking factor between 1990 and 2012 of 1.9 to the ADD discussed above. Garver used the historical daily production data that was provided to calculate historical MDD per capita instead of using a peaking factor.

Figure 3-5: Historical Average Day Per Capita Water Demand

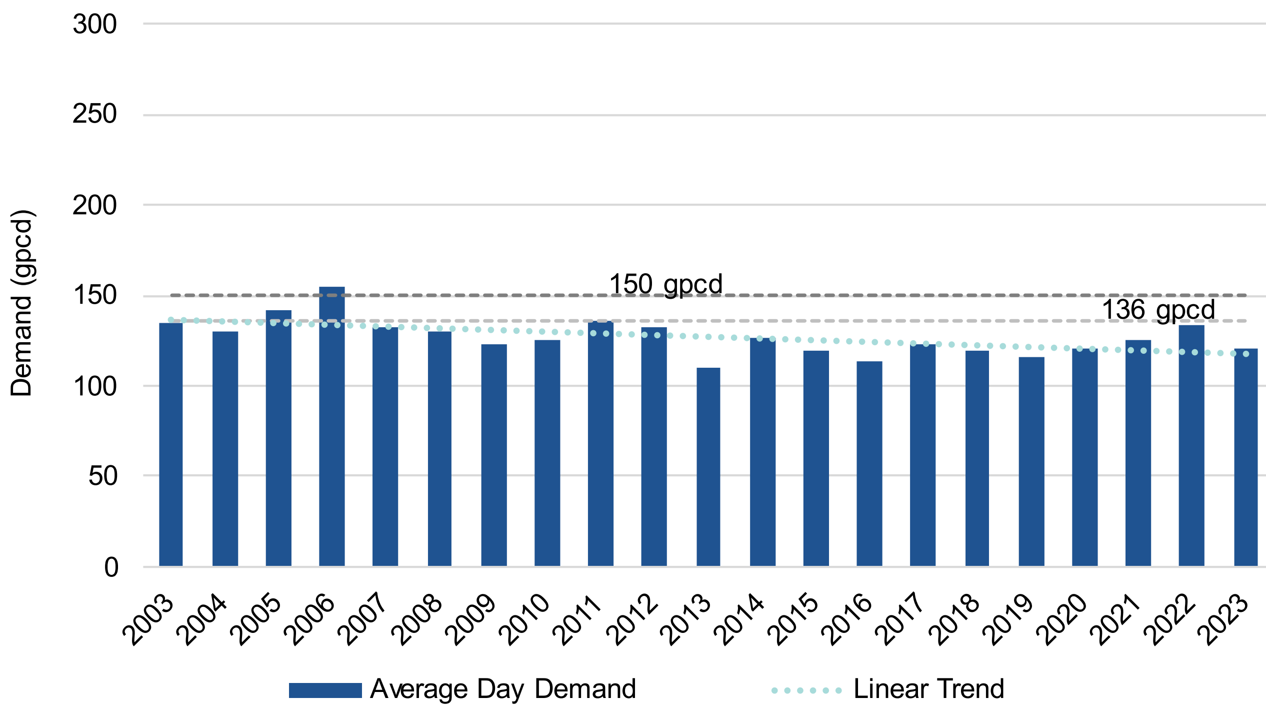
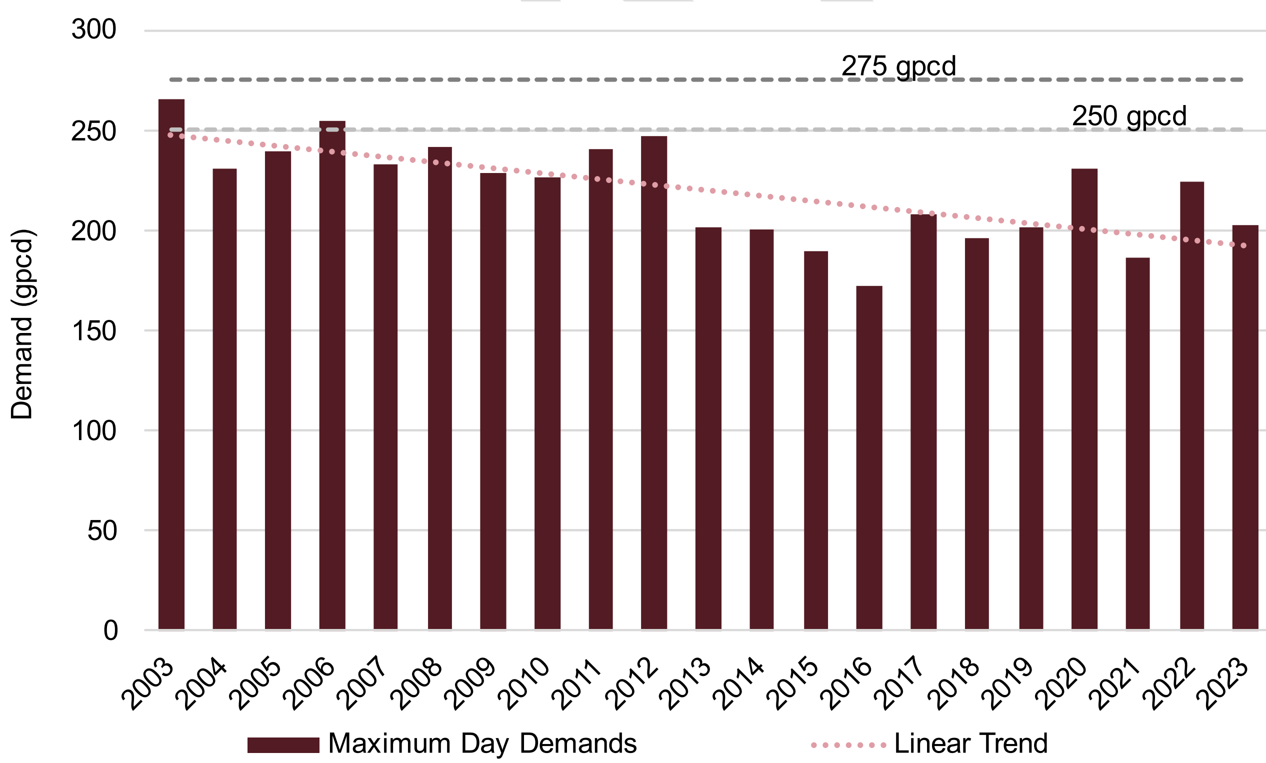


Figure 3-6: Historical Maximum Day Per Capita Water Demand



3.6 WATER DEMAND BY LAND USE

Garver used historical water consumption data from 2022 and GIS data to determine historical demands by existing land use. A GIS analysis was completed to determine the lot size, and the existing land use associated with each geolocated meter by extracting data for the nearest parcel. Table 3-3 summarizes the demands by land use category.

The projected demand rate values were used to determine future demand for new developments within the WSA, future water demand projections are discussed in more detail in Section 11.0. For single-family residential developments, the residential area was assumed to be about 80% of the total development area for high-density developments and 70% for low-density developments to account for the area of streets, detention ponds, and other open spaces.

Table 3-3: Historical and Projected Demands by Customer Class

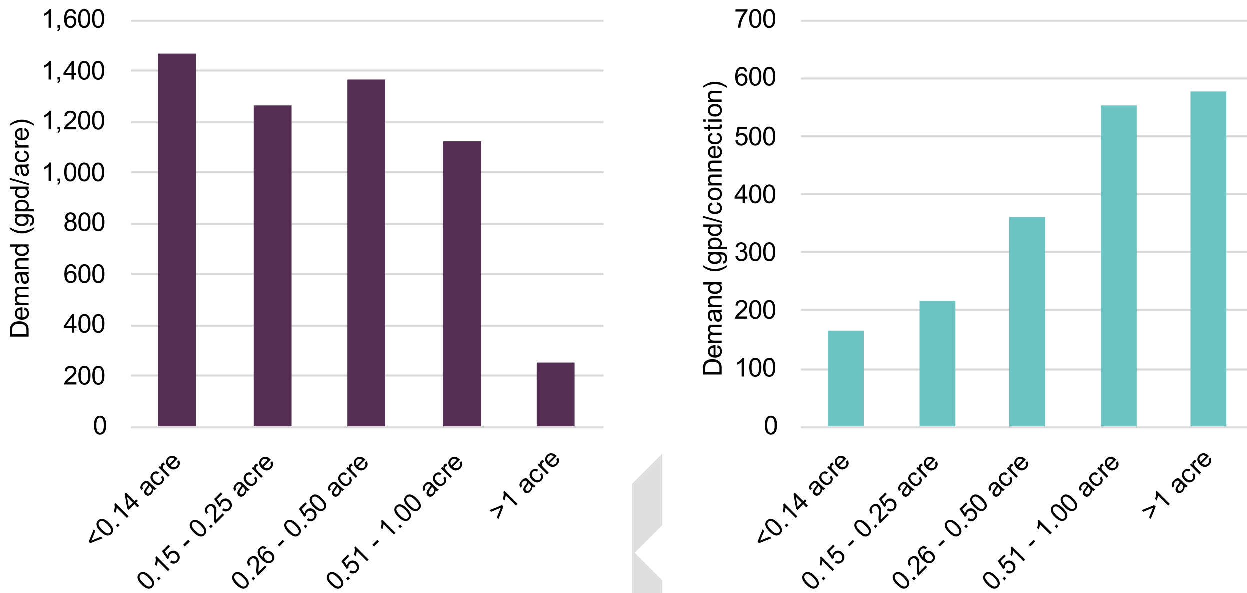
Customer Class	Customer Sub-Class	Total Annual Demand (MG)	Total Area (acre)	Historical Demand (gpd/acre)	Projected Demand Rate (gpd/acre)
Residential	Residential - Multi-Unit	678	700	2,654	2,700
	Residential - Single-Family Attached	195	311	1,714	1,800
	Residential - Single-Family Detached	3,062	7,575	1,107	See Table 3-4
Industrial	Light Industrial	91	293	848	900
	Heavy Industrial	41	94	1,182	1,200
Commercial	Commercial	562	1,745	3,218	3,300
	Office	290	403	1,974	2,000

As discussed in Section 3.4, residential users make up over 75% of all consumers within the WSA. Most residential users are classified as single-family detached lots. Due to the significant percentage of single-family detached users, further analysis was completed to determine the varied usage based on lot size. Table 3-4 and Figure 3-7 summarize the differences in usage related to differing lot sizes.

Table 3-4: Single-Family Detached Historical Demands by Lot Size

Lot Size (acre)	Number of Connections	Total Annual Demand (MG)	Total Area (acre)	Historical Demand (gpd/acre)	Projected Demand Rate (gpd/acre)	Historical Demand (gpd/connection)
<0.14	3,198	192	358	1,470	1,500	165
0.15 - 0.25	20,722	1,637	3,557	1,261	1,300	216
0.26 - 0.50	7,263	958	1,925	1,363	1,400	361
0.51 - 1.00	743	150	366	1,123	1,200	552
>1.00	595	125	1,369	251	350	577

Figure 3-7: Demand by Single-Family Detached Lot Sizes



3.7 SINGLE-FAMILY EQUIVALENTS

A single-family equivalent (SFE) value was determined using historical billed consumption data provided by NUA. SFE values are used to compare water system demands for other customer classes and the system overall to the demand of a typical single-family detached dwelling. Single-family residential demands are often used as the benchmark for demand planning because they tend to represent most system demands, and they tend to remain more stable over time compared to other benchmarks. Multi-unit, industrial, and commercial demands tend to vary significantly, and changes in these types of demands over time can cause variability in a water system's per capita demands. Once the single-family equivalent value has been determined, it can be used to express the system capacity as the number of single-family customer connections the water system can serve currently or in the future.

Garver used historical consumption data to determine the single-family equivalent value for the distribution system. The 2022 single-family water demand was calculated using the annual consumption of all meters classified as single-family with a diameter of 1-inch or less. The total demand was then divided by the total number of single-family meters within the system, for an estimated value of 250 gallons per day (gpd)/connection. These values are summarized in Table 3-5.

Table 3-5: Single-Family Equivalent Projection

Total Single-Family Demand		Number of Meters	ADD SFE Value (gpd/SFE)
(MG/year)	(MGD)		
3,067	8.4	33,641	250

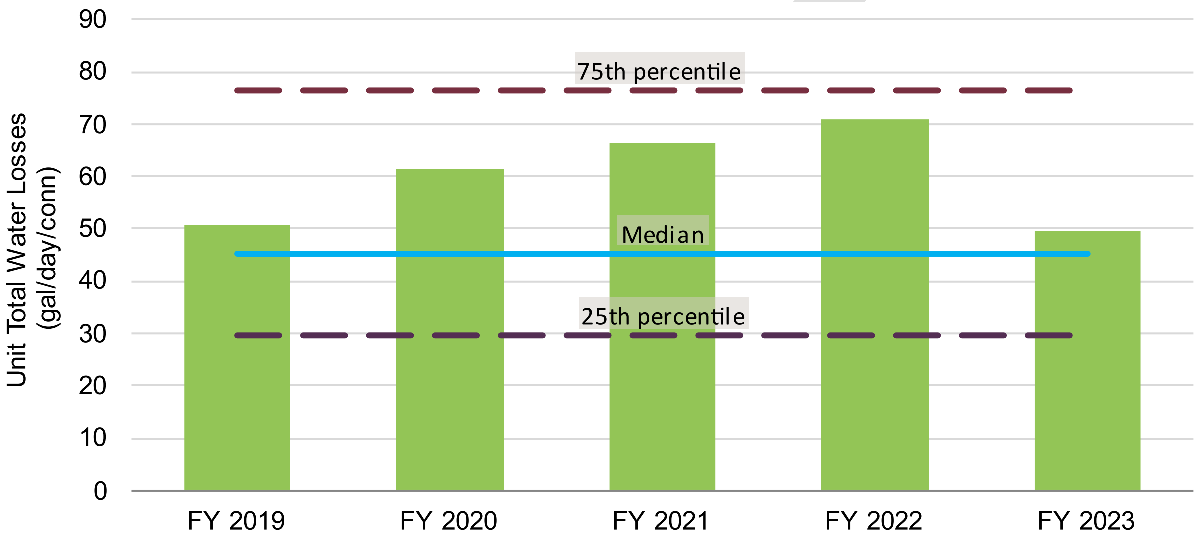
3.8 WATER LOSS

Garver reviewed water loss audits prepared by NUA for fiscal years 2019-2023. The audits were prepared by NUA using the American Water Works Association (AWWA) Free Water Audit Software.

Figure 3-8 summarizes the normalized total water losses for fiscal years 2019-2023. Total water losses are the sum of real losses (system leakage) and apparent losses (customer meter inaccuracies, unauthorized consumption, and data handling errors). Dividing the total losses by a measure of a water system's size (e.g., number of connections) provides a normalized key performance indicator for tracking losses over time and comparing losses to reference data. Urban water systems typically use total or real losses per connection as their primary normalized key performance indicator.

Figure 3-8 also shows the 25th percentile, median, and 75th percentile from the AWWA reference data included in the audit software. NUA's unit total water losses were between the median and the 75th percentile of the AWWA reference data for each fiscal year. During the 2023 fiscal year, NUA's unit total water losses were near the median compared to other systems. Higher losses near the 75th percentile in earlier years may be partially attributed to the impact of apparent losses caused by customer meter inaccuracies. NUA is currently implementing advanced water metering infrastructure to improve customer meter accuracy.

Figure 3-8: Total Unit Water Loss Between 2019 and 2023



4.0 POPULATION AND WATER DEMAND PROJECTIONS

4.1 POPULATION PROJECTIONS

Garver used the 1.5% annual growth rate projection included in the Norman Today report as the basis of the City's population projections through the year 2045 which are presented in Figure 4-1. It was assumed that the service population would be approximately 90% of the City's population, and the growth rate percentage was applied independently to both the City and NUA service populations.

Figure 4-1: City and NUA Service Area Population Projections

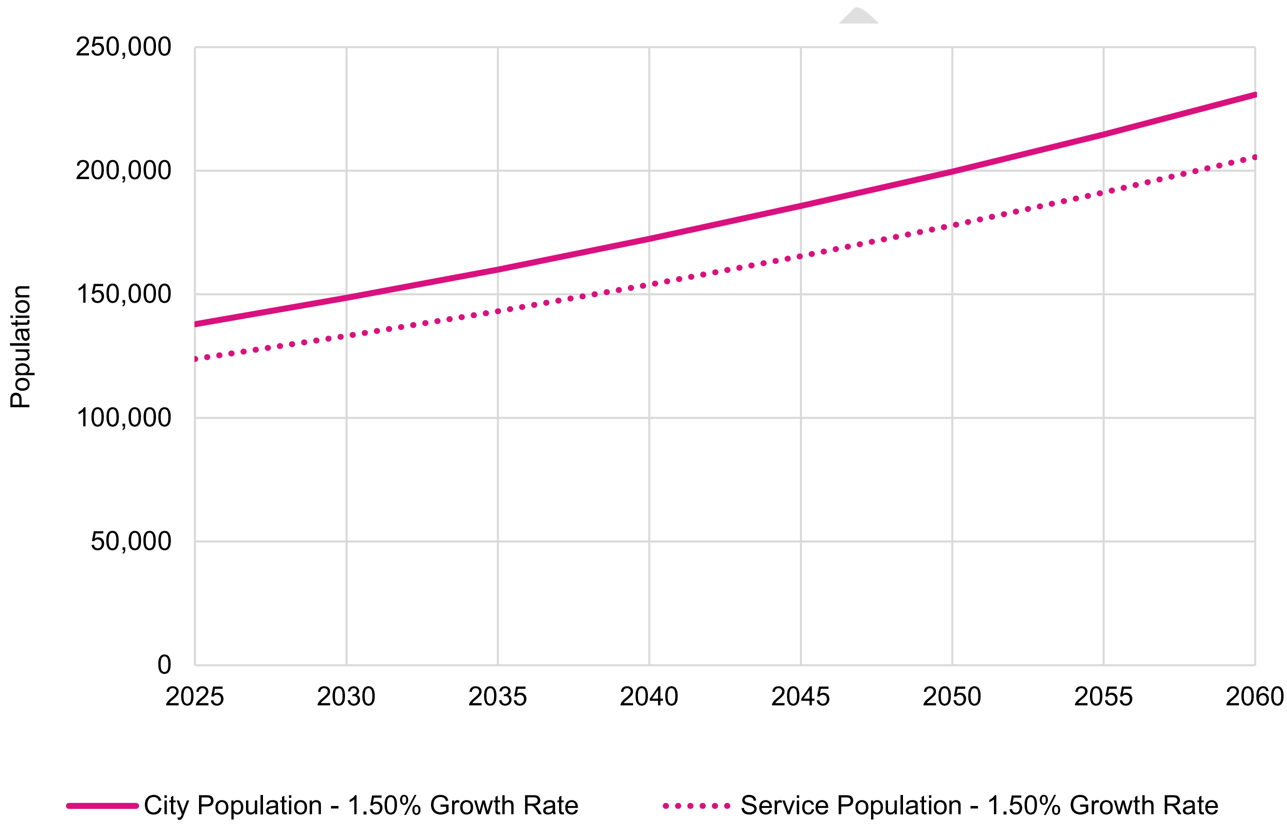
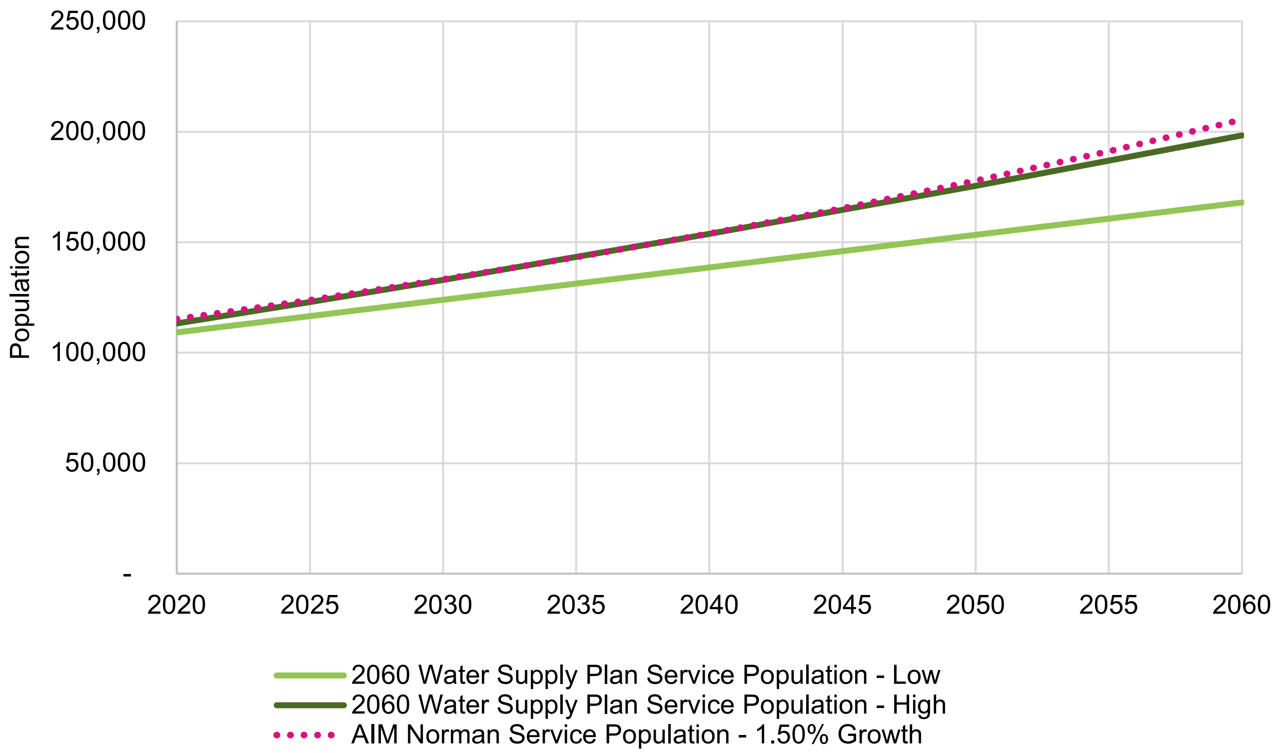


Figure 4-2 compares the new population projection to the population projection that was included in the 2060 Water Supply Plan. The population projection completed as part of this baseline development closely aligns with the earlier population projection included in the 2060 Water Supply Plan.

Figure 4-2: 2060 Water Supply Plan vs. AIM Norman Population Projection



4.2 WATER DEMAND PROJECTIONS

As discussed in Section 3.3 and Section 3.5, the historical service population was used to determine the ADD and MDD per capita values of 136 gpcd and 250 gpcd, respectively. Production data was supplied for the years 1990-2022. To determine the ADD and MDD per capita demands for the system, only data after 2008 was considered to capture values that more closely reflect current usage. In addition to the values discussed above, a reserve capacity of 10% was included for both the ADD and MDD projections to remain consistent with the 2060 Water Supply Plan. Garver recommends the inclusion of a reserve capacity to mitigate any potential changes to per capita demand because of a new large user, unanticipated growth, or severe droughts. The projected ADD and MDD at the projected population is shown in Table 4-1.

Table 4-1: Projected Water Demands

Year	Service Population	ADD (MGD)	ADD Reserve Capacity (MGD)	ADD Total (MGD)	MDD (MGD)	MDD Reserve Capacity (MGD)	MDD Total (MGD)	Single-Family Equivalent[1]
2025	123,865	16.8	1.7	18.5	31.0	3.1	34.1	74,121
2030	133,155	18.1	1.8	19.9	33.3	3.3	36.6	79,680
2035	143,142	19.5	1.9	21.4	35.8	3.6	39.4	85,656
2040	153,877	20.9	2.1	23.0	38.5	3.8	42.3	92,080
2045	165,418	22.5	2.2	24.7	41.4	4.1	45.5	98,986

Notes:

1. Based on projected ADD with reserve capacity and a value of 250 gpd/SFE as discussed in Section 3.7.

Figure 4-3 and Figure 4-4 show the historical consumption and the projected ADD and MDD through 2045. Projections through the year 2045 were used for CIP development. The projections through 2060 were developed based off the land use capacity of the service area and were used to determine sizing.

Figure 4-3: Historical and Projected Average Day Demand

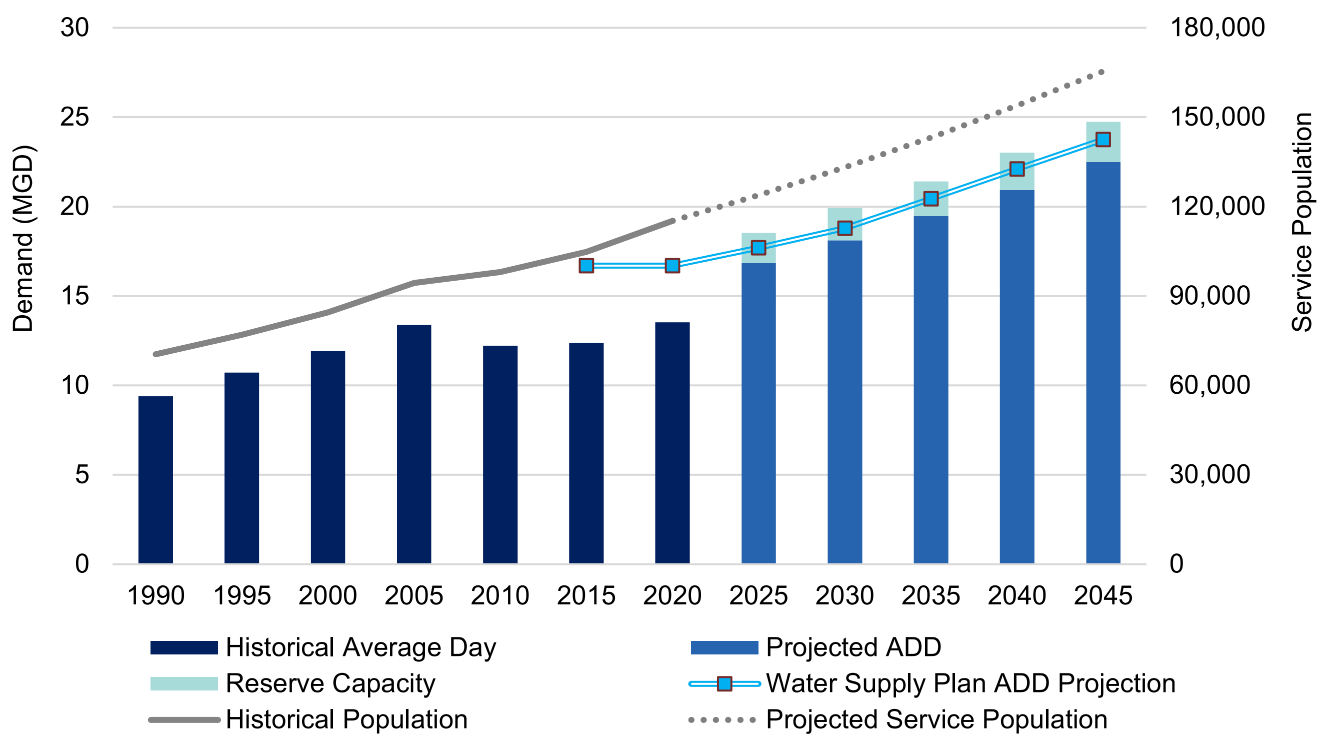
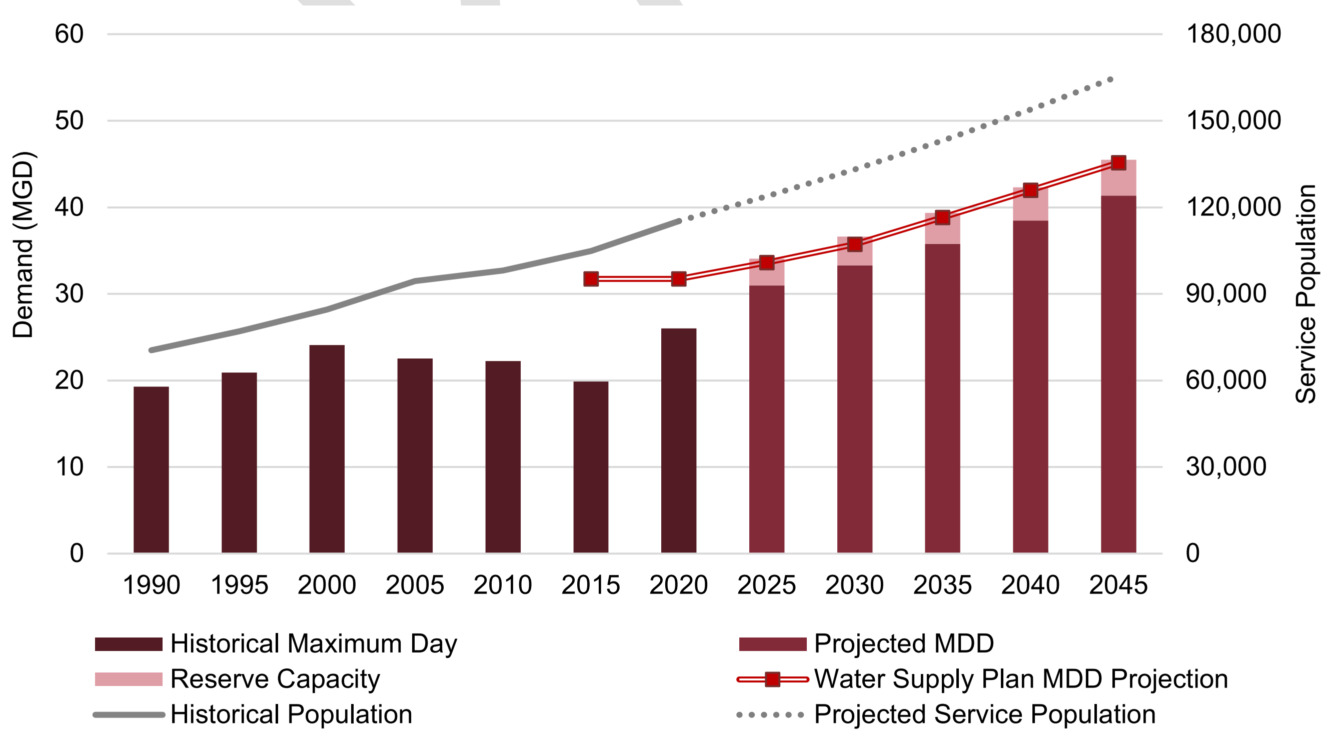


Figure 4-4: Historical and Projected Maximum Day Demand



5.0 WATER QUALITY

Water quality data was provided by NUA and downloaded from the Oklahoma Drinking Water Watch database. To gain a better understanding of the current system and identify current system challenges the following sample results were analyzed:

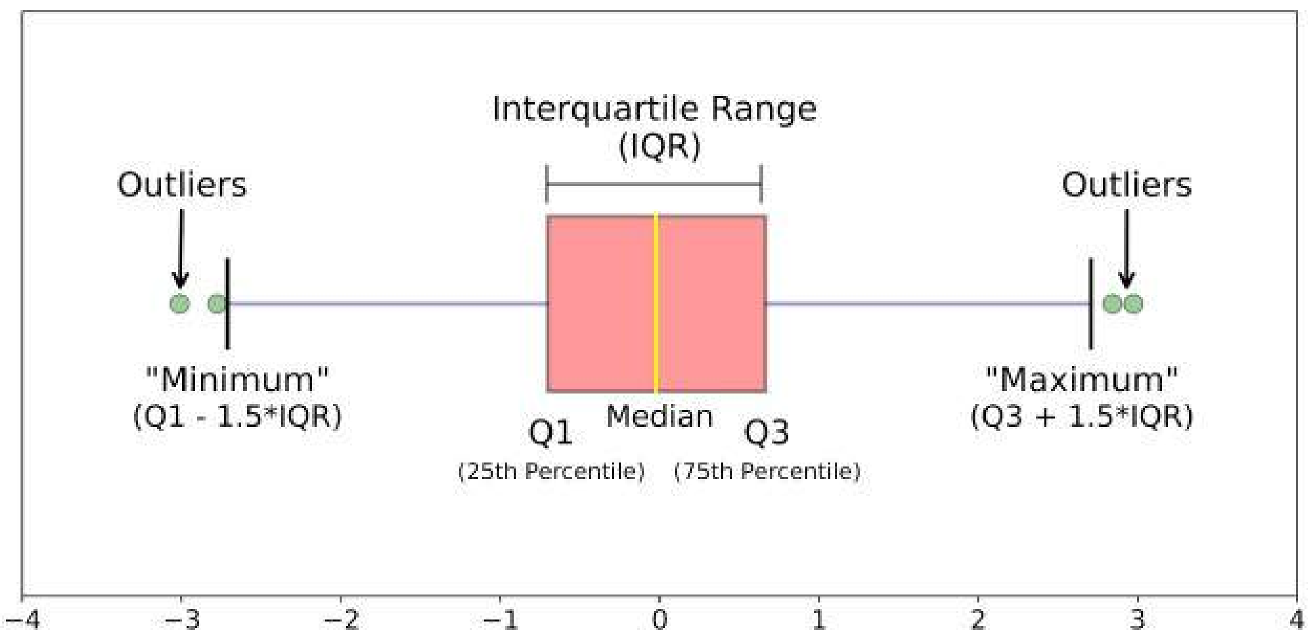
- Bacteriological
- Disinfection Byproducts
- Disinfectant Residual
- Lead and Copper
- Nitrite

5.1 DISINFECTANT RESIDUAL

Disinfectant residuals serve as a surrogate for the potential for or presence of microbial activity. Disinfectant residuals are measured as total chlorine in chloraminated systems and are typically lowest in areas with high water age, sediment, corrosion products, biofilm, or other sources of disinfectant demand, or where undisinfected groundwater enters the distribution system. A box and whisker plot for the disinfectant residual data provided by NUA from the regulatory compliance sampling conducted between 2021 and 2023 is shown in Figure 5-2.

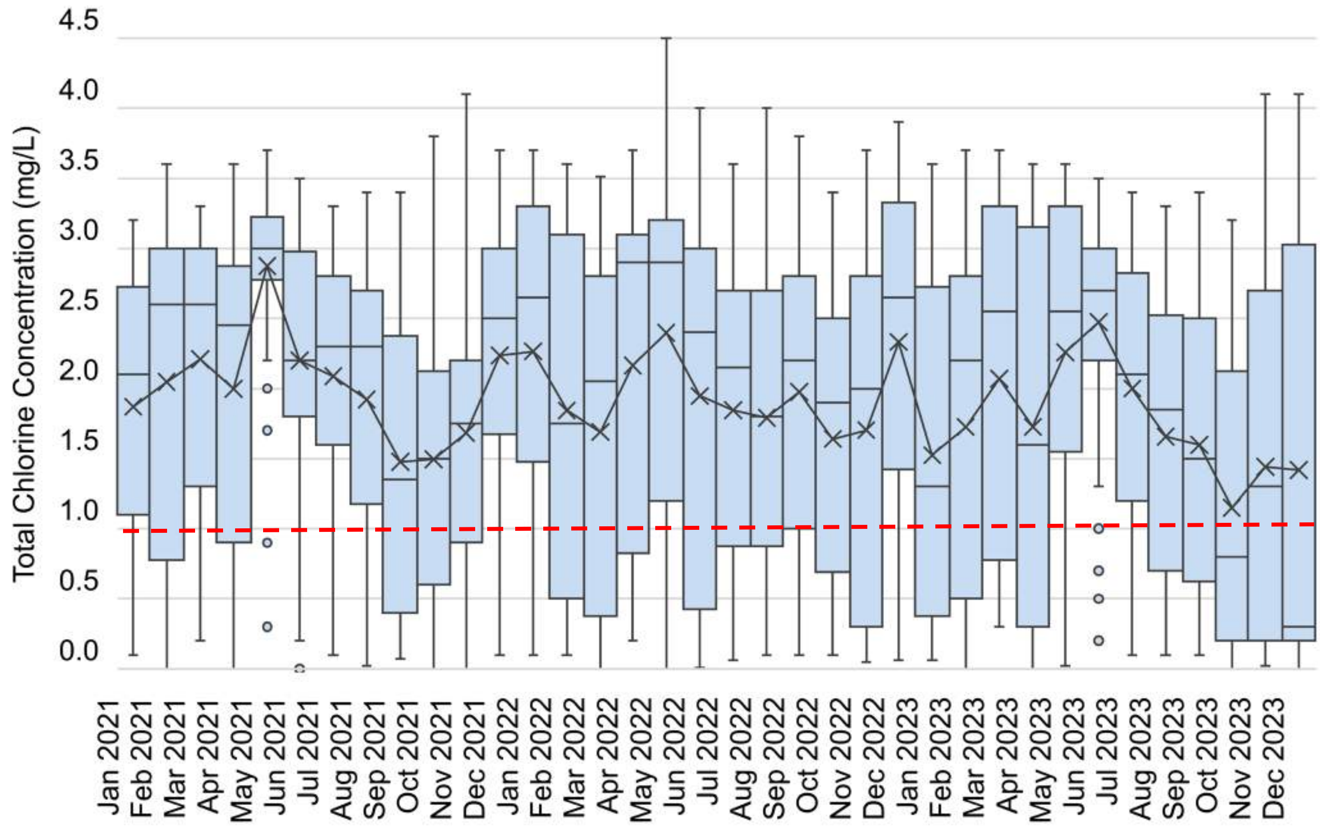
A box and whisker plot was used to present a graphical representation of the data and shows the minimum, maximum, mean, median, interquartile range, and outliers of a data set. Figure 5-1 shows an example box and whisker plot with outlier points. The average total chlorine residuals for the entire system, denoted by "x" symbols in Figure 5-2 ranged from 1.1 to 2.9 milligrams per liter (mg/L).

Figure 5-1: Example Box and Whisker Plot



Oklahoma Department of Environmental Quality (ODEQ) regulations require a minimum total chlorine residual of 1.0 mg/L throughout the water distribution system. The regulatory minimum total chlorine residual is shown as a dashed red line on Figure 5-2. Several total chlorine residual samples, denoted by "o" symbols, were below 1.0 mg/L in the data provided. Finished water leaving the Vernon Campbell WTP typically has a total chlorine residual of at least 3.0 mg/L. However, undisinfected groundwater is pumped directly into the distribution system at multiple well sites, which is likely contributing to low total chlorine residuals at some locations. A new centralized groundwater blending and disinfection facility that will address this issue is currently in the design phase.

Figure 5-2: Total Chlorine Residual Box Plots by Month Between 2021 and 2023



5.2 TOTAL COLIFORM AND E. COLI

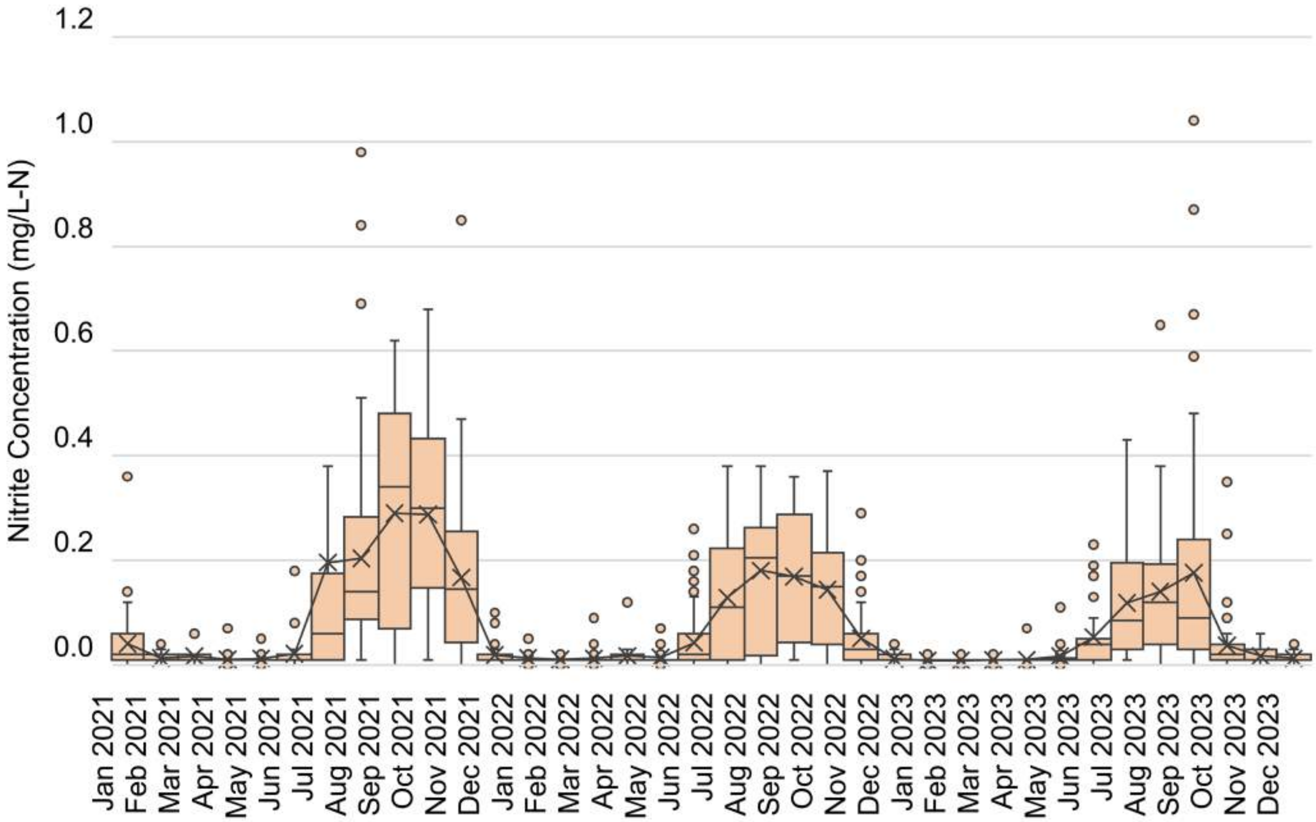
The Revised Total Coliform Rule requires monitoring of total coliform and E. coli according to a sample siting plan and schedule specific to each water system. According to the Oklahoma Drinking Water Watch database, NUA must currently sample 100 sites per month. A Level 1 Assessment to find sanitary defects is triggered when 5% of routine/repeat samples in the same month are total coliform-positive.

Bacteriological sample results were obtained from the Oklahoma Drinking Water Watch database for 2020 through 2023. According to these sample results, 5% of the samples during the months of October 2023 and May 2022 were total coliform-positive. No samples between 2020 and 2023 tested positive for E. coli.

5.3 NITRIFICATION

Nitrification is the microbial process by which ammonia is oxidized to nitrite and nitrate. It occurs in chloraminated systems due to the presence of free ammonia from the decay of chloramines, excess ammonia addition during the formation of chloramines, or possibly from source water. Nitrification typically begins in areas with low disinfectant residuals and can lead to additional disinfectant residual loss, excessive microbial activity, and a drop in pH, which can lead to corrosion. Nitrification is typically identified based on total chlorine, monochloramine, free ammonia, nitrite, and nitrate measurements. The average nitrite for the entire system, denoted by "x" symbols in Figure 5-3, increased during the last summer months of each year, reaching as high as 0.3 mg/L-N in 2021.

Figure 5-3: Nitrite Box Plots by Month Between 2021 and 2023



5.4 DISINFECTION BYPRODUCTS

Disinfection byproducts can form when a disinfectant reacts with natural organic matter. Some disinfection byproducts are associated with negative impacts on human health, and two groups of disinfection byproducts have maximum contaminant levels (MCLs) based on locational running annual averages under the Stage 2 Disinfectants/Disinfection Byproducts Rule. Two groups of regulated disinfection byproducts are measured in NUA's distribution system:

- Five regulated haloacetic acids (HAA5), with a MCL of 60 micrograms per liter (µg/L)
- Total trihalomethanes (TTHM), with an MCL of 80 µg/L

NUA provided quarterly sampling results for HAA5 and TTHM at four sampling locations for 2021 through 2023. All individual HAA5 and TTHM samples were below 60 µg/L and 80 µg/L, respectively. The maximum HAA5 and TTHM detected concentrations for 2023 were 10.1 µg/L and 14.9 µg/L, respectively.

5.5 LEAD AND COPPER

Lead and copper typically enter drinking water via release from service line and premise plumbing materials. Lead is associated with negative human health outcomes, even at low levels. Copper is primarily associated with aesthetic complaints but could have health impacts at high levels.

The Lead and Copper Rule (LCR) set action levels for copper and lead at 1.3 milligrams per liter (mg/L) and 0.015 mg/L, respectively, based on the 90th percentile tap sample collected during each monitoring period. If the 90th percentile sample exceeds an action level, the water system must take steps to reduce lead or copper release, such as service line replacement or optimization of corrosion control treatment.

NUA provided lead and copper sample results from tap sampling in the distribution system between 2011 and 2023. Table 5-1 summarizes lead and copper data between 2011 and 2023. The 90th percentile samples for both copper and lead are well below their action levels.

The proposed Lead and Copper Rule Improvements (LCRI), which was finalized in October 2024 and will have a compliance date in 2027, will decrease the lead action level to 0.010 mg/L and maintain the LCR's copper action level. Additionally, it will require water systems to revise their sampling sites to preferentially sample from sites with known lead service lines or lead premise plumbing. NUA staff reported that NUA collects lead and copper samples from locations that are known or expected to have lead service lines or lead premise plumbing. NUA will need to confirm the service line and/or premise plumbing materials at tap sampling sites to maintain compliance with the LCRI's sampling site tier structure. Should new sites be needed for LCRI compliance, it is possible that the measured lead levels will increase.

Table 5-1: 90th Percentile Lead and Copper Concentrations Between 2011 and 2023

Monitoring Period	Copper		Lead		
	90th Percentile Concentration (mg/L)	Number of Samples Exceeding 1.3 mg/L Action Level	90th Percentile Concentration (mg/L)	Number of Samples Exceeding 0.015 mg/L Previous Action Level	Number of Samples Exceeding 0.010 mg/L Current Action Level[1]
01/01/2011 - 06/30/2011	0.0224	0	0	0	0
01/01/2012 - 06/30/2012	0.0167	0	0	0	0
07/01/2012 - 12/31/2012	0.0144	0	0	0	0
01/01/2013 - 12/31/2013	0.0922	0	0.000634	0	0
01/01/2018 - 12/31/2018	0.078	0	0	0	0
01/01/2019 - 12/31/2019	0.07	0	0	0	0
01/01/2020 - 06/30/2020	0.109	0	0	0	1
07/01/2020 - 12/31/2020	0.086	0	0	0	0
01/01/2021 - 12/31/2021	0.066	0	0	0	0
01/01/2022 - 12/31/2022	0.177	0	0.000365	0	0
01/01/2023 - 12/31/2023	0.155	0	0.000720	0	0

Notes:
1. The future action level represents the LCRI new action level and has no bearing on past compliance with the LCR.

6.0 WATER SYSTEM EVALUATION CRITERIA

Design criteria and regulatory requirements from a variety of sources were assembled to develop the evaluation criteria for analysis of the distribution system. Specifically, documents from the following sources were reviewed:

- American Water Works Association (AWWA) Manuals
- City of Norman 2023 Engineering Design Criteria and Standard Specifications (Norman EDC)
- International Fire Code (IFC)
- Oklahoma Department of Environmental Quality (ODEQ)

Table 6-1 summarizes the evaluation criteria that were used to evaluate the water system's performance and identify potential capital improvement projects.

Table 6-1: Water System Evaluation Criteria

Criteria	Limiting Source	Description
Supply	ODEQ	ODEQ requires documentation demonstrating an adequate quantity of water was available and that water will meet or exceed current drinking water standards.
Water Lines	Norman EDC	All water lines along section lines and arterial streets must be at least 12-inch diameter. All water lines along half-section lines and all collector streets should be a minimum of 8-inch diameter. All other lines shall be minimum 6-inch diameter.
Pumping	ODEQ	All pumping stations shall have a minimum of two pumping units. With any pump out of service the remaining pump(s) shall be capable of providing the maximum pumping demand of the system.
Storage	ODEQ	System must be able to maintain sufficient storage capacity to meet domestic demands and fire flow demands over a 24-hour period while maintaining 25 pounds per square inch (psi) throughout distribution system.
Minimum Pressure	ODEQ	A minimum pressure of 25 psi shall be maintained, including during fire flow events.
	NUA target level of service (2018 Modeling Update Report)	A minimum pressure of 40 pounds per square inch shall be maintained, if possible.
Fire Flow	IFC	NUA enforces the IFC, 2018 edition. A system-wide minimum pressure criteria of 25 psi is used to determine available fire flow.
	NUA target level of service (2018 Modeling Update Report)	A minimum available fire flow of 1,500 gpm at 25 psi residual pressure, if possible.
Maximum Flow Velocity	AWWA (guideline)	Water distribution lines should not experience a maximum flow velocity of greater than 6 ft/s. (Note: Guideline is not a regulatory requirement and was used to identify water lines for potential replacement.)
Maximum Head Loss Gradient	AWWA (guideline)	The maximum head loss gradient for smaller pipes (diameter < 16 inches) should not exceed 7 ft/1,000 ft. The maximum head loss gradient for larger pipes (diameter ≥ 16 inches) should not exceed 3 ft/1,000 ft. (Note: Guideline is not a regulatory requirement and was used to identify water lines for potential replacement.)

7.0 HYDRAULIC MODEL UPDATE

Garver evaluated the water distribution system using Autodesk's InfoWater Pro hydraulic modeling software. Garver migrated the InfoWorks WS Pro model developed for the 2018 Modeling Update to InfoWater Pro and updated the hydraulic model based on information provided by NUA. Elevations throughout the model were assigned using the one-meter contours published by the United States Geological Survey. The following sections describe the hydraulic model update in more detail.

7.1 MODEL SUPPLY AND PUMPING

The hydraulic model includes a single fixed head reservoir to represent the Vernon Campbell WTP clearwells. The model also includes the individual pumps supplying each pressure plane. Manufacturer pump curves provided by NUA were digitized and assigned to the corresponding pumps in the model. The controls for the pumps were modeled based on supervisory control and data acquisition (SCADA) setpoints for lead/lag pump operations and speeds based on tank levels provided by NUA. The Main Pressure Plane (MPP) Pump Station is typically controlled based on tank levels in the Brookhaven Elevated Storage Tank (EST), and the High Pressure Plane (HPP) Pump Station is typically controlled based on tank levels in the HPP EST.

The OKC connection is included in the model as a fixed head reservoir with a flow control valve set to the typical flow rate of 1 MGD.

The wells are included in the model as individual fixed head reservoirs and pumps at each active well location. Active wells constructed in 2018 were added to the model based on the GIS database provided by NUA. Well pump curves and operating water level depths are based on information provided by NUA where available.

7.2 MODEL WATER LINES

All water lines from the existing InfoWorks WS Pro water model were migrated to the new hydraulic model with their corresponding diameter and Hazen-Williams C factor (C) attributes. The C-values on the existing model water lines ranged from 100 to 150, and Table 7-1 provides a summary of the C-value range of existing model water lines by material. Additional water lines (with corresponding diameter, material, and construction date attributes) were added to the new hydraulic model based on the water line GIS shapefile provided by NUA. Garver also modified existing water line attributes and alignments where they differed from the current GIS data. New and modified model water lines are shown in Map 7-1.

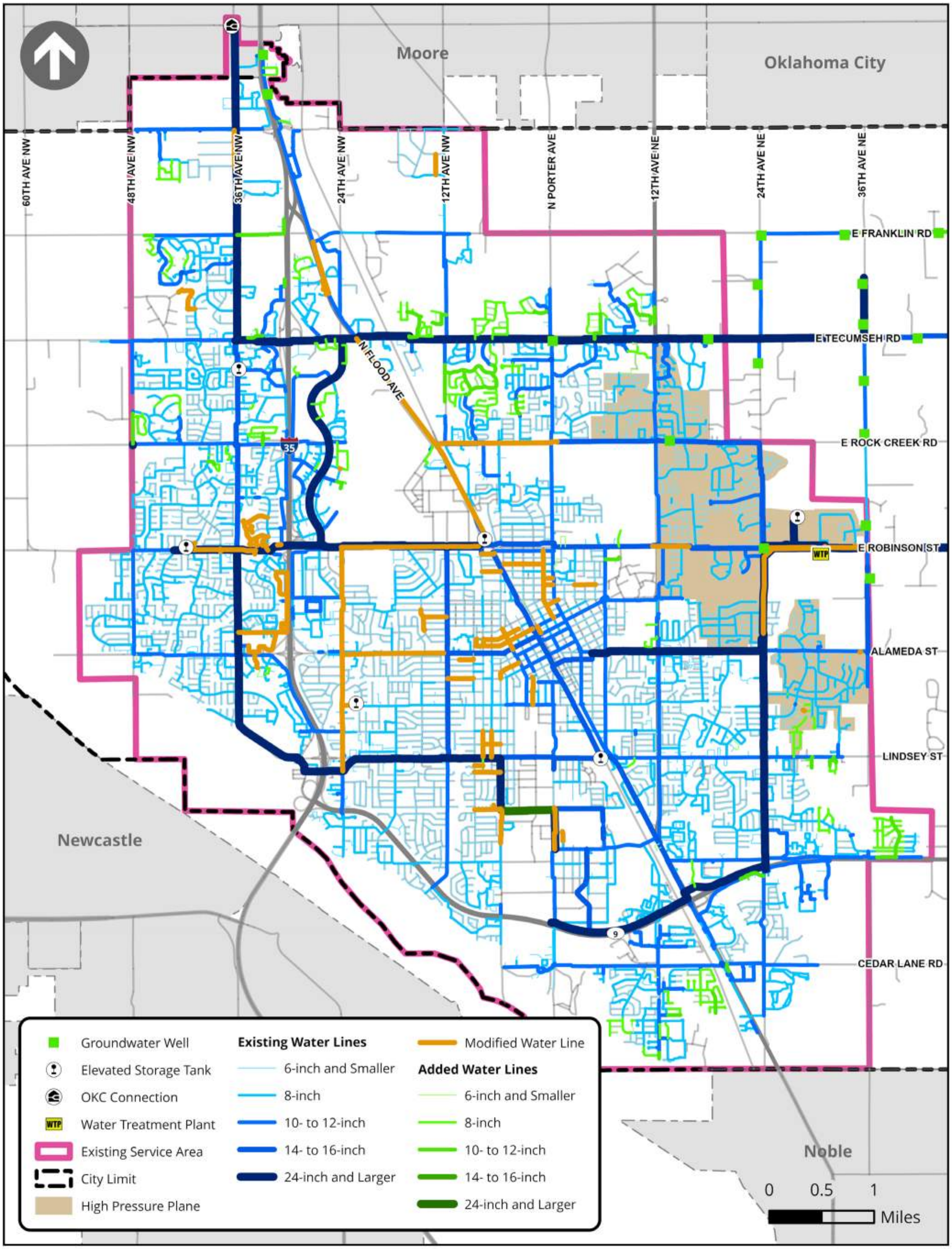
For the new or modified water lines the material was used to determine the appropriate C-value. A C-value of C=130 was assigned to ductile iron water lines, C=140 was assigned to all water lines specified as polyvinyl chloride (PVC) and high-density polyethylene (HDPE), and C=140 was assigned to all remaining water lines with an unspecified material. Water line lengths were calculated by the modeling software. Table 7-2 provides a summary of the C-value ranges for the new or modified water lines.

Table 7-1: Summary of Existing Model Water Line C-Values

Water Line Material	C-Value Range
Asbestos Cement	142–147
Cast Iron	100–110
Concrete	120
Copper	140–149
Ductile Iron	130–140
Galvanized Pipe	120
HDPE	150
PVC	134-150
Reinforced Concrete	120
Steel	120

Table 7-2: Summary of New or Modified Model Water Line C-Values

Water Line Material	C-Value Range
Ductile Iron	130
HDPE	140
PVC	140
Reinforced Concrete	140
Steel	140


Moore
Oklahoma City
Newcastle
Noble
60TH AVE NW
48TH AVE NW
36TH AVE NW
24TH AVE NW
12TH AVE NW
N PORTER AVE
12TH AVE NE
24TH AVE NE
36TH AVE NE
E FRANKLIN RD
E TECUMSEH RD
N FLOOD AVE
E ROCK CREEK RD
E ROBINSON ST
ALAMEDA ST
LINDSEY ST
CEDAR LANE RD
35
9
WTP
Groundwater Well
Elevated Storage Tank
OKC Connection
Water Treatment Plant
Existing Service Area
City Limit
High Pressure Plane
Existing Water Lines
6-inch and Smaller
8-inch
10- to 12-inch
14- to 16-inch
24-inch and Larger
Modified Water Line
Added Water Lines
6-inch and Smaller
8-inch
10- to 12-inch
14- to 16-inch
24-inch and Larger
0 0.5 1
Miles

7.3 MODEL STORAGE

All distribution system storage tanks from the existing InfoWorks water model were migrated to the new hydraulic model with corresponding volume, level, elevation, and tank mixing model attributes.

7.4 MODEL DEMANDS

Historical and projected water demands were presented in Section 3.3 and Section 4.2, respectively. For the existing system assessment, the distribution system was evaluated using demands projected for the year 2025, not including the 10% reserve capacity. These demands represent potential ADD and MDD for a year with hot and dry summer conditions.

7.4.1 SPATIAL DISTRIBUTION OF DEMANDS

The spatial distribution of demand was completed by dividing NUA system demands into five major components as listed below and summarized in Table 7-3. The updated demands for ADD and MDD conditions are presented in Map 7-2 and Map 7-3, respectively. The list below also provides information on how demands for each category were developed. All meter locations were based on geolocated meter data provided by NUA.

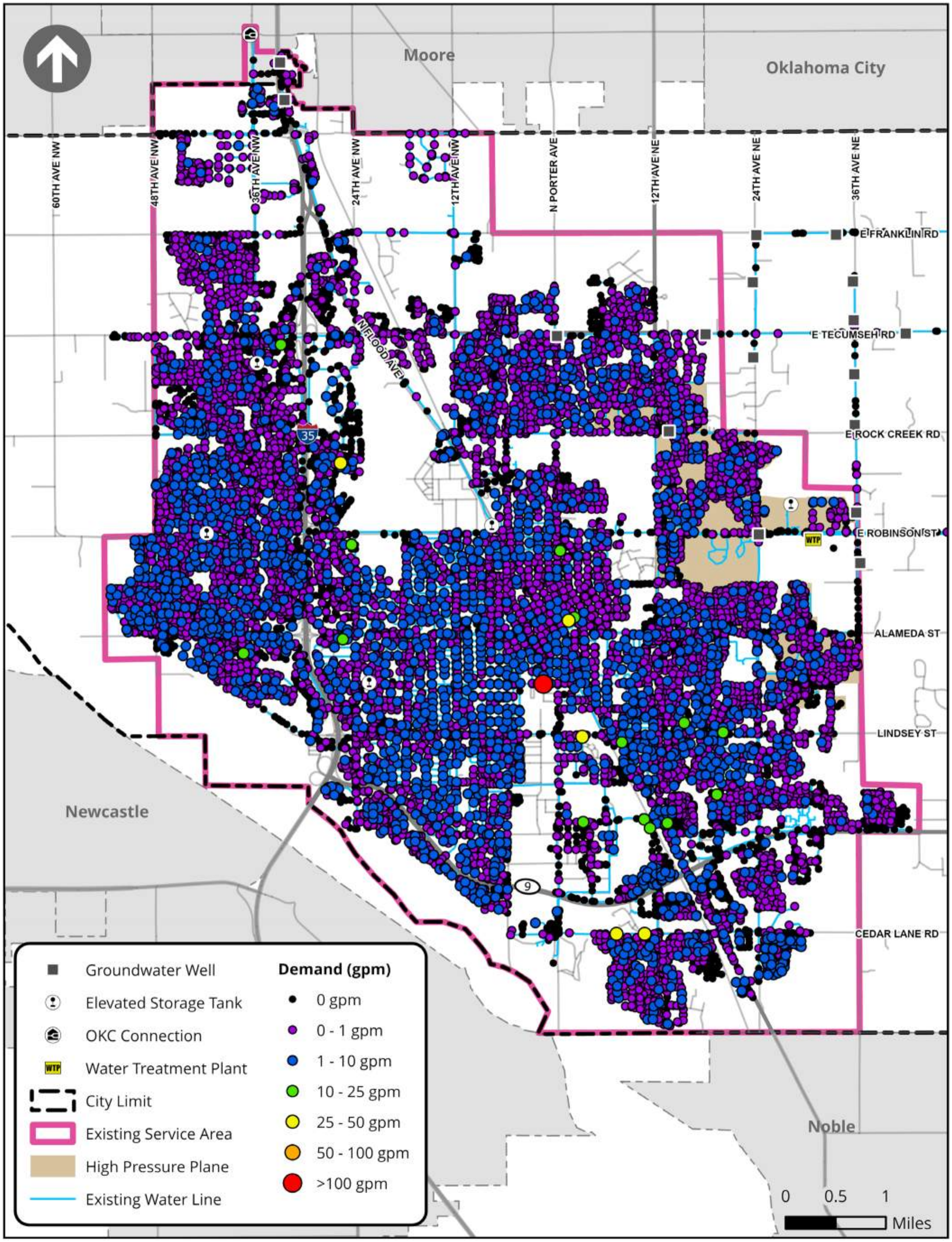
- Residential Single-Family Detached and Single-Family Attached: This category assigned demands using billed consumption for each water residential meter that was classified as single-family, duplex, or apartment house, and 1-inch and smaller. All connections below a minimum value of 187.5 gpd/connection were assigned the minimum value and those connections where the value exceeded the minimum were assigned their respective historical average or maximum consumption values.
- Residential Sprinkler: This category assigned demands using billed consumption for all residential sprinkler meters. All connections below a minimum value of 250 gpd/connection were assigned the minimum value and those connections where the value exceeded the minimum were assigned their respective average or maximum consumption values.
- Residential Metered Apartment: This category assigned demands using billed consumption for each water residential meter that was classified as an individual metered apartment. All connections below a minimum value of 125 gpd/connection were assigned the minimum value and those connections where the value exceeded the minimum were assigned their respective average or maximum consumption values.
- Residential Multi-Family: This category assigned demands using billed consumption for all remaining residential water meters. All connections below a minimum value of 250 gpd/connection were assigned the minimum value and those connections where the value exceeded the minimum were assigned their respective average or maximum consumption values.
- Non-Residential: This category assigned demands using billed consumption for all non-residential meters. All connections below a minimum value of 187.5 gpd/connection were assigned the minimum value and those connections where the value exceeded the minimum were assigned their respective average or maximum consumption values.

Table 7-3: Demand Allocation Summary

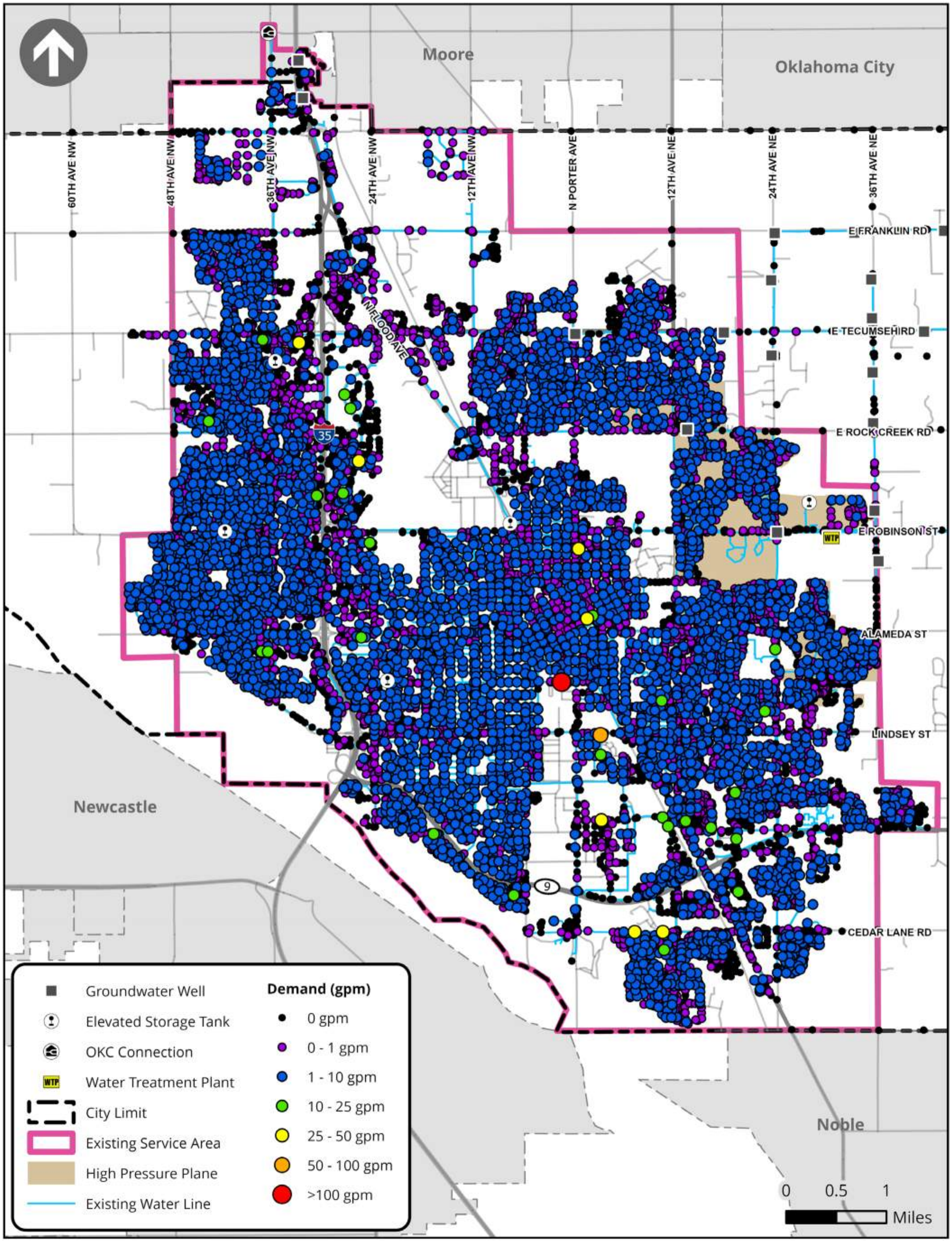
Label	Type	Service	Class	Size	Minimum Value (gpd/connection)
Residential Single-Family Detached and Single-Family Attached	Residential	Water	Single-Family, Duplex, Apartment House	1-inch, 3/4-inch	187.5
Residential Sprinkler	Residential	Sprinkler	All	All	250

Label	Type	Service	Class	Size	Minimum Value (gpd/connection)
Residential Metered Apartment	Residential	Water	Individual Metered Apartment	All	125
Residential Multi-Family	Residential	Water	All Other	All	250
Non-Residential	Commercial, Municipal, Public Authority, Industrial, Senior	Water	All	All	187.5

Map 7-2: Hydraulic Model Spatial Demand Updates - Average Day Demand



Map 7-3: Hydraulic Model Spatial Demand Updates - Maximum Day Demand



7.4.2 DIURNAL CURVE DEVELOPMENT

SCADA data between January 2019 and February 2024 was prepared by NUA. The data supplied was used to develop diurnal curves for both average and maximum day conditions, using average and maximum week representative time periods. For each set of conditions, two one-week periods from different years were selected and analyzed to develop each curve. To develop the average day diurnal curve, data from April 8 to 15, 2022, and April 16 to 22, 2023, was used. To develop the maximum day diurnal curve, data from August 6 to 13, 2021, and July 20 to 24, 2022, was used.

Hourly SCADA data for tank elevations and supply flows into the NUA distribution system from the representative weekly periods were used to determine the hourly outflow. The difference between the inflow and the change in storage was used to determine the total usage for the system for each hour. Demand factors were then determined by dividing the hourly usage by the average production for the given day. The calculated demand factors were then used to create the respective diurnal curve for each scenario.

Demand factors at the same time step varied day to day due to specific system conditions on a given day. Because of this variability, the data for each hourly time step was organized into its 25th percentile, median, and 75th percentile to better determine overall trends within the data. From these series, the design diurnal was created to achieve maximum peaking factors near the 75th percentile. The ADD and MDD diurnal curves are presented in Figure 7-1 and Figure 7-2, respectively.

Figure 7-1: Main Pressure Plane Average Day Diurnal from April 2022

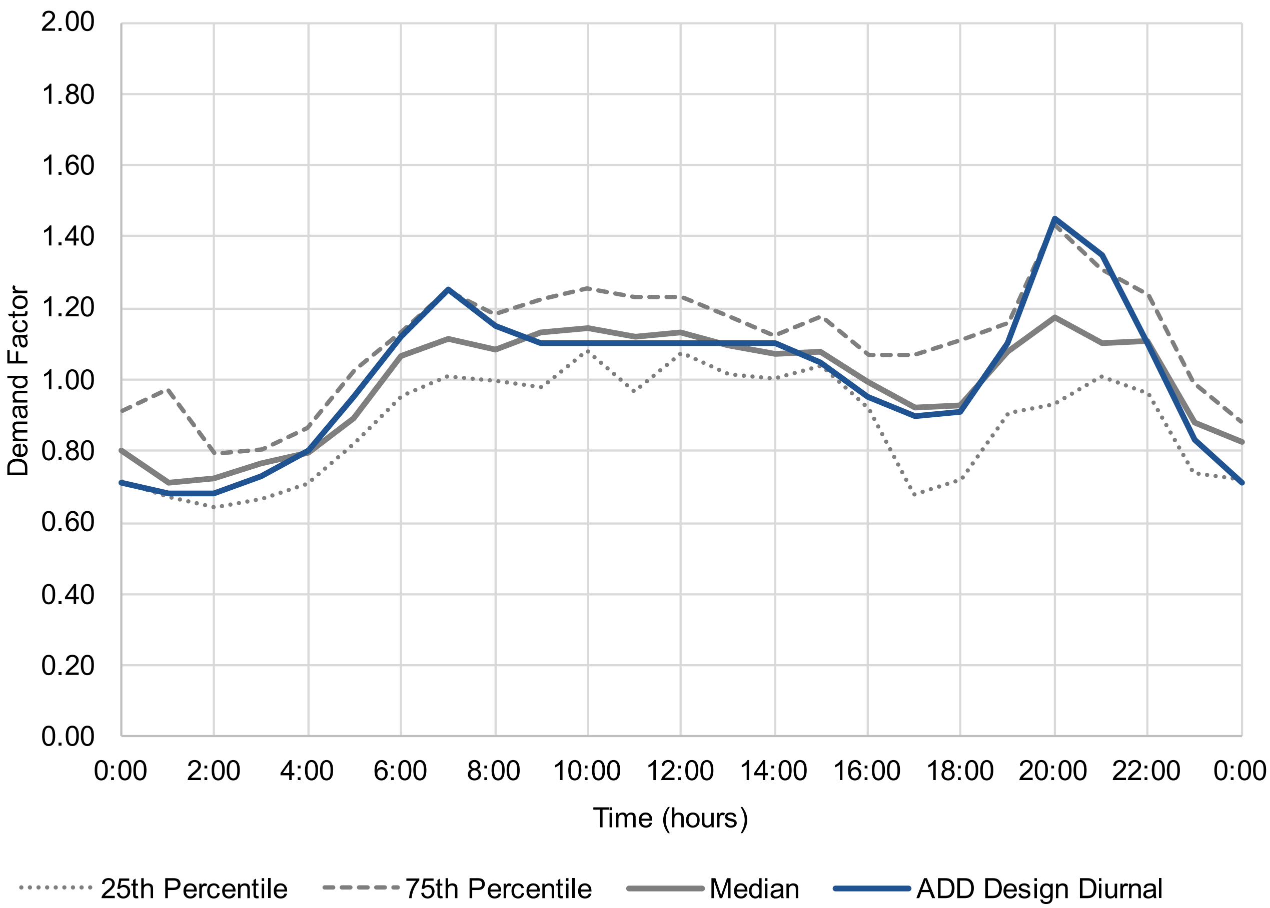


Figure 7-2: Main Pressure Plane Maximum Day Diurnal Curve from August 2021 and July 2022

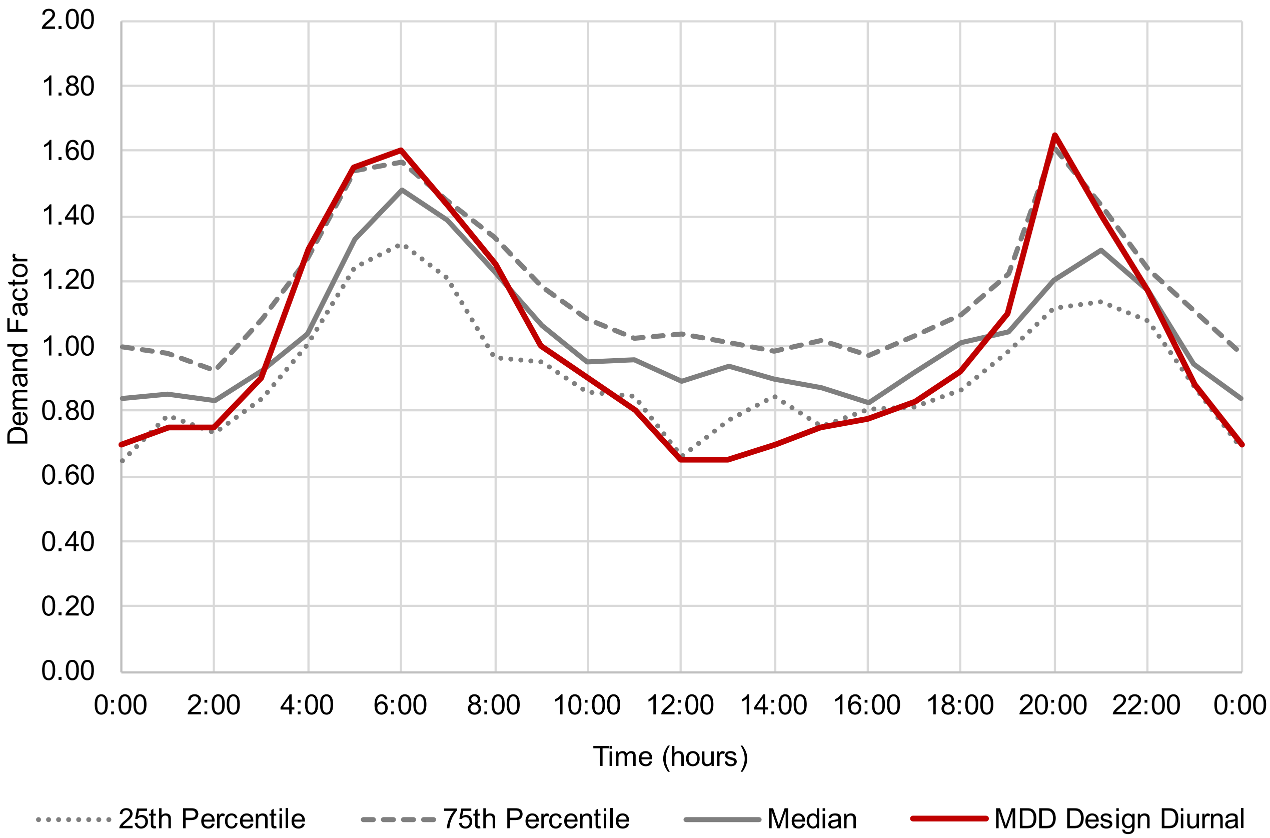
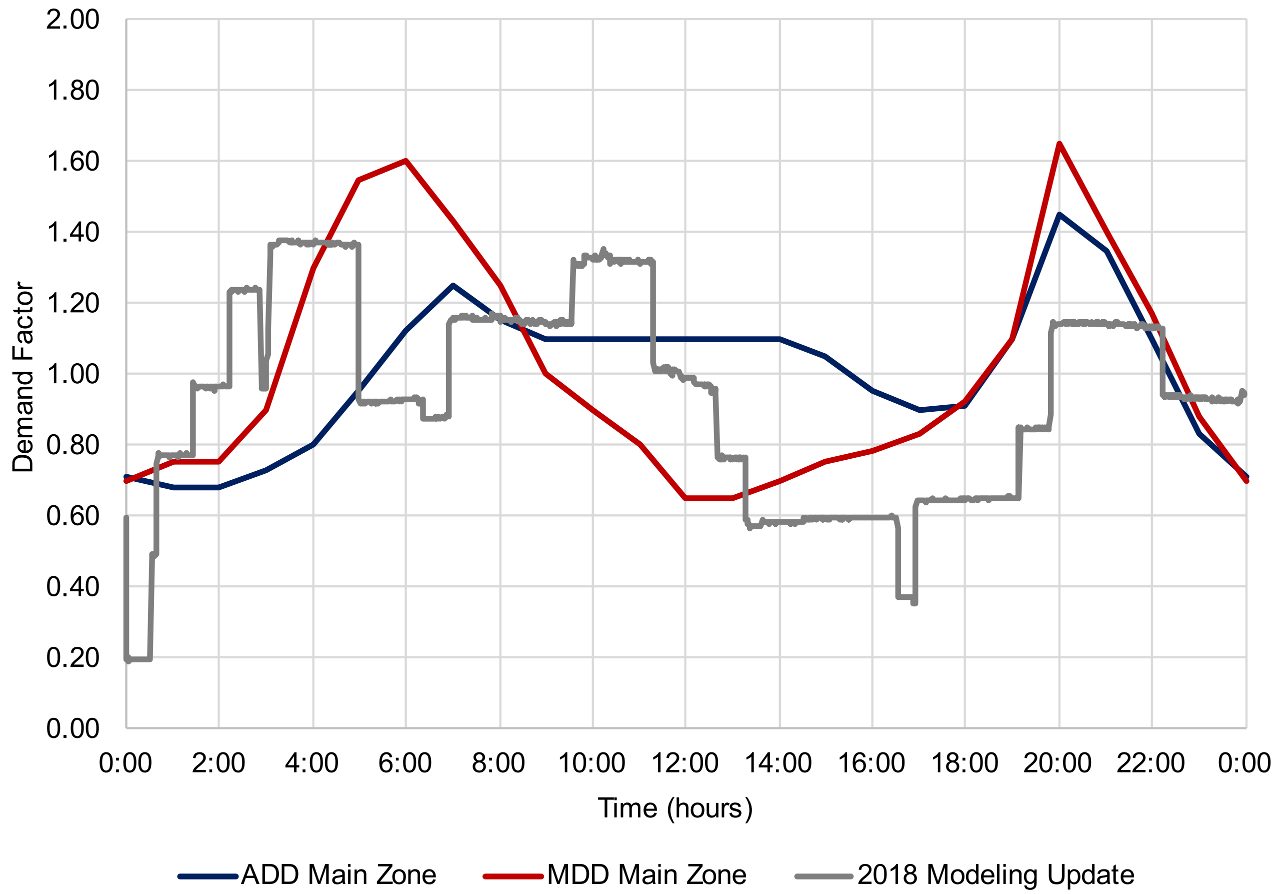


Figure 7-3 compares the ADD and MDD diurnals discussed above to the system diurnal presented in the 2018 Modeling Update and used for previous modeling efforts by others. The previous diurnal was part of a greater weeklong diurnal pattern that was created using SCADA data from August 23 to September 2, 2016. The maximum peaking factor in the MDD design diurnal occurred around midday on Thursday and had a value around 1.6. This aligns with the MDD maximum peaking factor shown above Figure 7-2.

The previous modeling efforts only used the Monday portion of the weeklong pattern. It was determined that updating the diurnal pattern using the new SCADA data produced by NUA would create a more conservative diurnal than the ones previously used.

Figure 7-3: Updated Diurnals Compared to Previous System Diurnal



7.5 MODEL SCENARIOS

Scenarios used to evaluate the existing NUA water distribution system are summarized in Table 7-3.

Table 7-4: System Assessment Scenario Summary

Scenario	Extended Period Simulation / Steady State	Demands	Sources	Results Analyzed
Average Day Demand	Extended Period Simulation	Average Day Demands	OKC = 1.0 MGD Surface Water = 8.5 MGD Groundwater Wells = 6.5 MGD	Maximum Pressure
Maximum Day Demand	Extended Period Simulation	Maximum Day Demands	OKC = 1.0 MGD Surface Water = 17.7 MGD Groundwater Wells = 11.4 MGD	Minimum Pressure, Maximum Pipe Velocity, Maximum Head Loss Gradient
Fire Flow	Steady State	Maximum Day Demands	OKC = 1.0 MGD Surface Water = 17.7 MGD Groundwater Wells = 11.4 MGD	Available Fire Flow

8.0 FIELD DATA COLLECTION

8.1 CONTINUOUS PRESSURE MONITORING

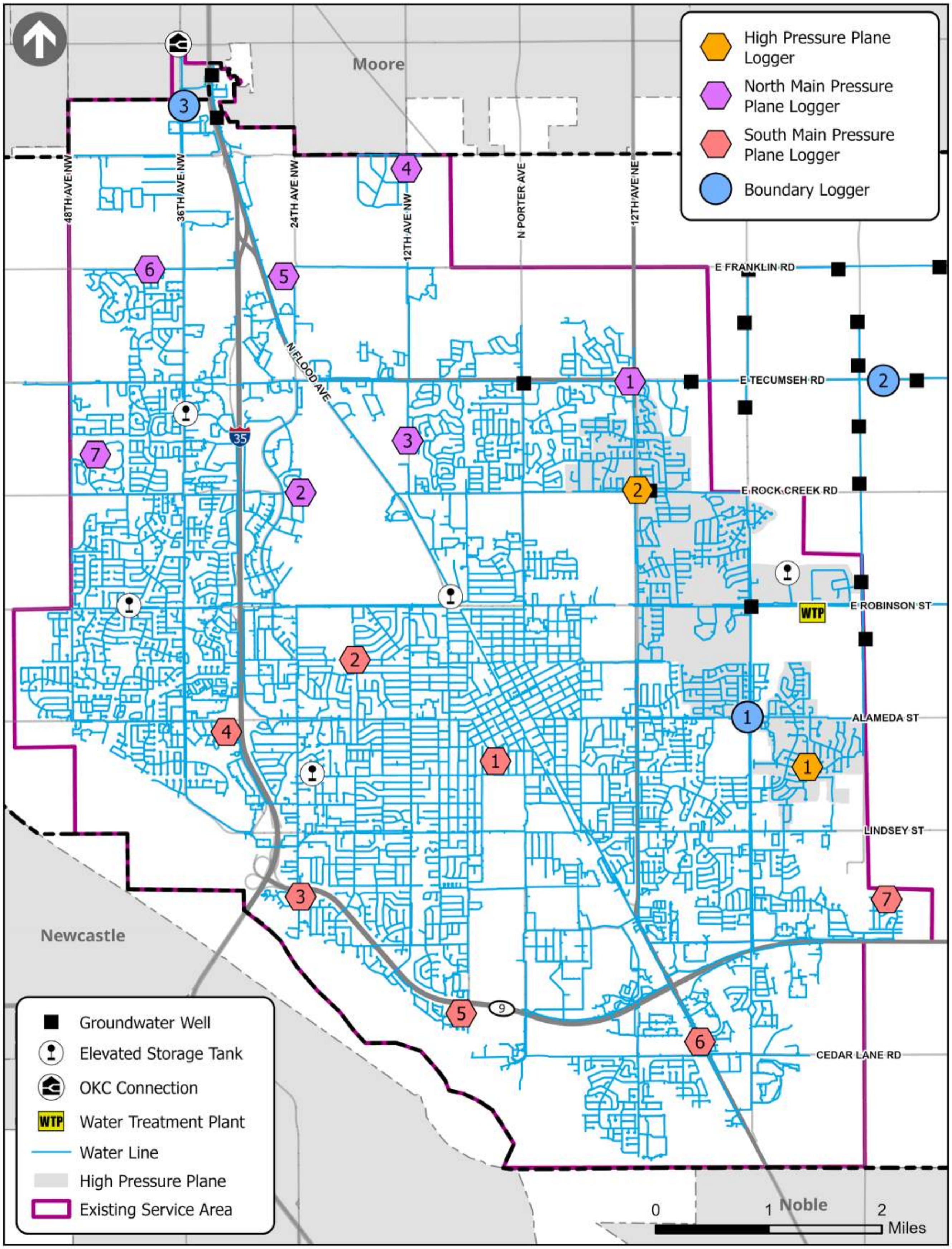
Pressures were monitored at 19 different locations within the distribution system to aid in model calibration. Garver conducted three rounds of continuous pressure monitoring and used a total of ten pressure loggers. The first round was used to collect pressure data within the southern portion of the MPP between April 11 and April 22, 2024. The second round was used to collect pressure data within the northern portion of the MPP between April 23 and May 3, 2024. For the third round, the pressure monitors were installed within the HPP between May 3 and May 9, 2024. Boundary loggers were installed during the first pressure logger deployment at three different locations within the distribution system between April 11 and April 23, 2024. A summary of the continuous pressure monitoring loggers is presented in Table 8-1, and the locations are shown in Map 8-1.

The Field Data Collection Plan which includes details and results related to all flow tests completed can be found in Appendix C

Table 8-1: Pressure Logger Locations

Deployment	Logger	Location	Start Date	End Date	Average Pressure (psi)
Southern MPP	1	North of West Boyd Street & South University Boulevard	4/11/2024	4/22/2024	60
Southern MPP	2	North Sherry Avenue & Denison Drive	4/11/2024	4/22/2024	64
Southern MPP	3	McKown Drive & 24th Avenue Southwest	4/11/2024	4/22/2024	76
Southern MPP	4	Ed Noble Parkway (Charleston's Parking Lot)	4/11/2024	4/22/2024	63
Southern MPP	5	South Canadian Trails Drive (Rivermont Assisted Living)	4/11/2024	4/22/2024	82
Southern MPP	6	North of Highway 77 & East Cedar Lane Road	4/11/2024	4/22/2024	56
Southern MPP	7	Wiltshire Drive & Bellatona Boulevard	4/11/2024	4/22/2024	54
Northern MPP	1	12th Avenue Northeast & East Tecumseh Road	4/25/2024	5/3/2024	62
Northern MPP	2	West Rock Creek Road	4/23/2024	5/3/2024	53
Northern MPP	3	12th Avenue Northwest & Piper Street	4/23/2024	5/3/2024	57
Northern MPP	4	South of West Indian Hills Road & 12th Avenue Northwest	4/23/2024	5/3/2024	46
Northern MPP	5	Cleveland County Jail	4/23/2024	5/3/2024	61
Northern MPP	6	West Franklin Road & Pimlico Avenue	4/23/2024	5/3/2024	54
Northern MPP	7	Crittenden Link Road	4/23/2024	5/3/2024	69
HPP	1	Day Break Drive & Summit Crossing Parkway	5/3/2024	5/9/2024	58
HPP	2	East Rock Creek Road & 12th Avenue Northeast	5/3/2024	5/9/2024	67
Boundary Logger	1	East Alameda Street & 24 Avenue Northeast	4/11/2024	4/23/2024	46
Boundary Logger	2	East Tecumseh Road & 36th Avenue Northeast	4/15/2024	4/23/2024	75
Boundary Logger	3	North of West Indian Hills Road & 36th Avenue Northwest	4/12/2024	4/23/2024	52

Map 8-1: Logger Deployment Overview



Box and whisker plots were generated for the 15-minute pressure data for each logger. Figure 5-1, In the distribution system water quality section, shows an example box and whisker plot with outlier points. The box and whisker plots for each group of pressure loggers are presented in Figure 8-1 through Figure 8-4. The data was used to check how pressures typically varied throughout the day and to assist in determining static pressures values used in the hydraulic model. Field readings are presented in a box and whisker diagram format to contribute a graphical representation of descriptive statistics such as minimum, maximum, mean, median, interquartile range, and outliers of a data set. The minimum to maximum range of the pressure logger data was narrower in areas near ESTs and wider in areas impacted by pumping operations. During the field data collection period, the Vernon Campbell WTP backwash pump was out of service, and a bypass backwash valve was used to supply water from the MPP back to the Vernon Campbell WTP, which led to lower pressures for short durations near the Vernon Campbell WTP. These lower pressures appear as outliers in the box and whisker plots. A time series chart for pressure logger data is shown in comparison with model data in Section 9.1.

Figure 8-1: Northern Main Pressure Plane - Pressure Loggers

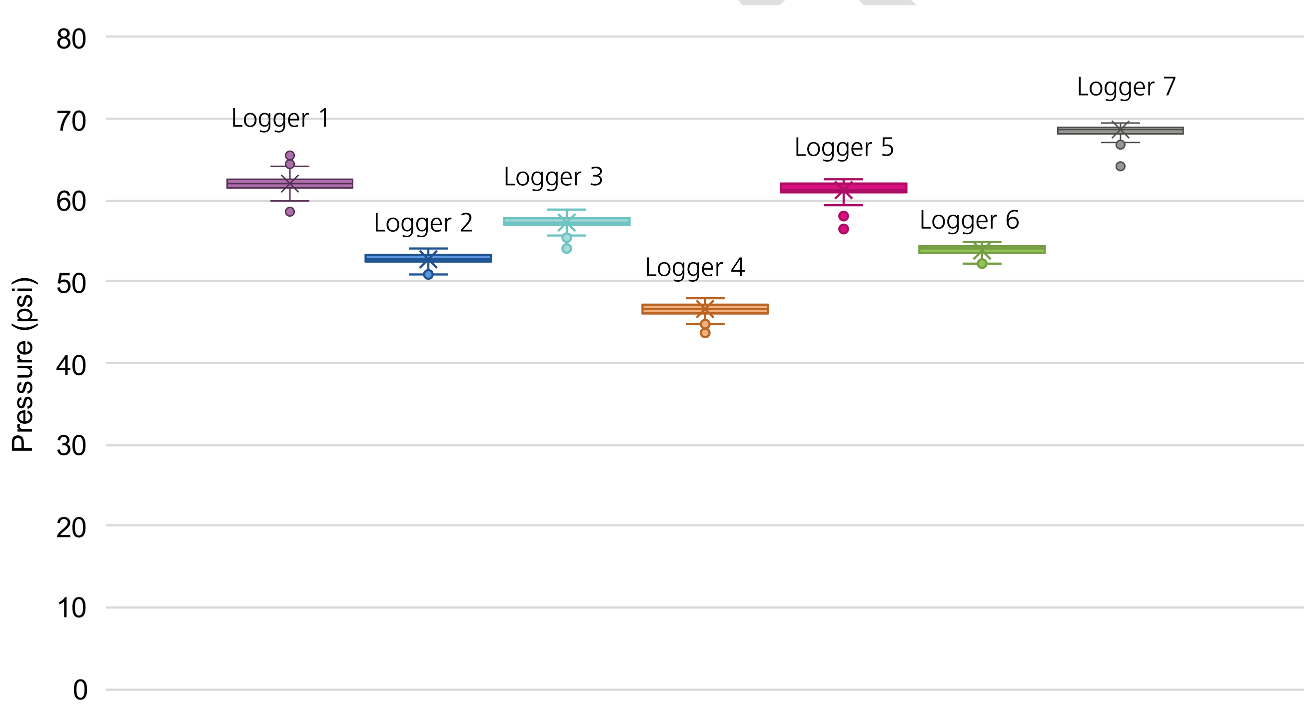


Figure 8-2: Southern Main Pressure Plane - Pressure Loggers

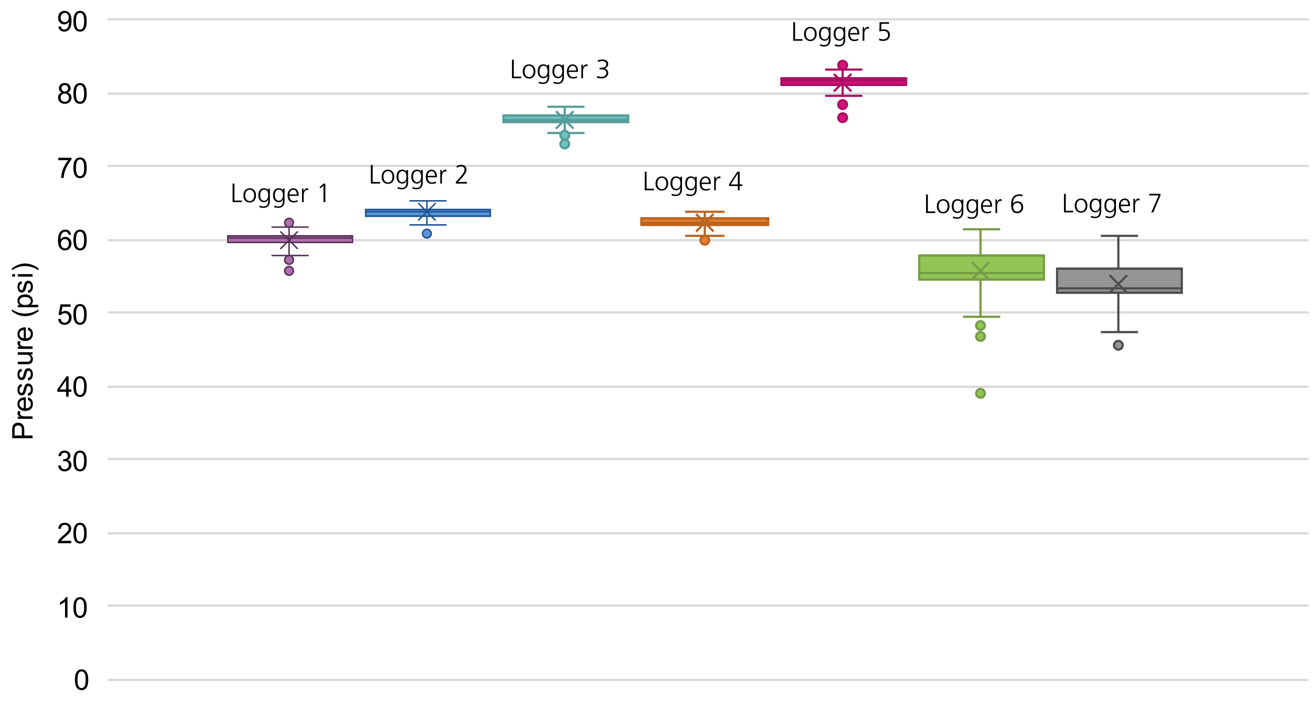


Figure 8-3: High Pressure Plane - Pressure Loggers

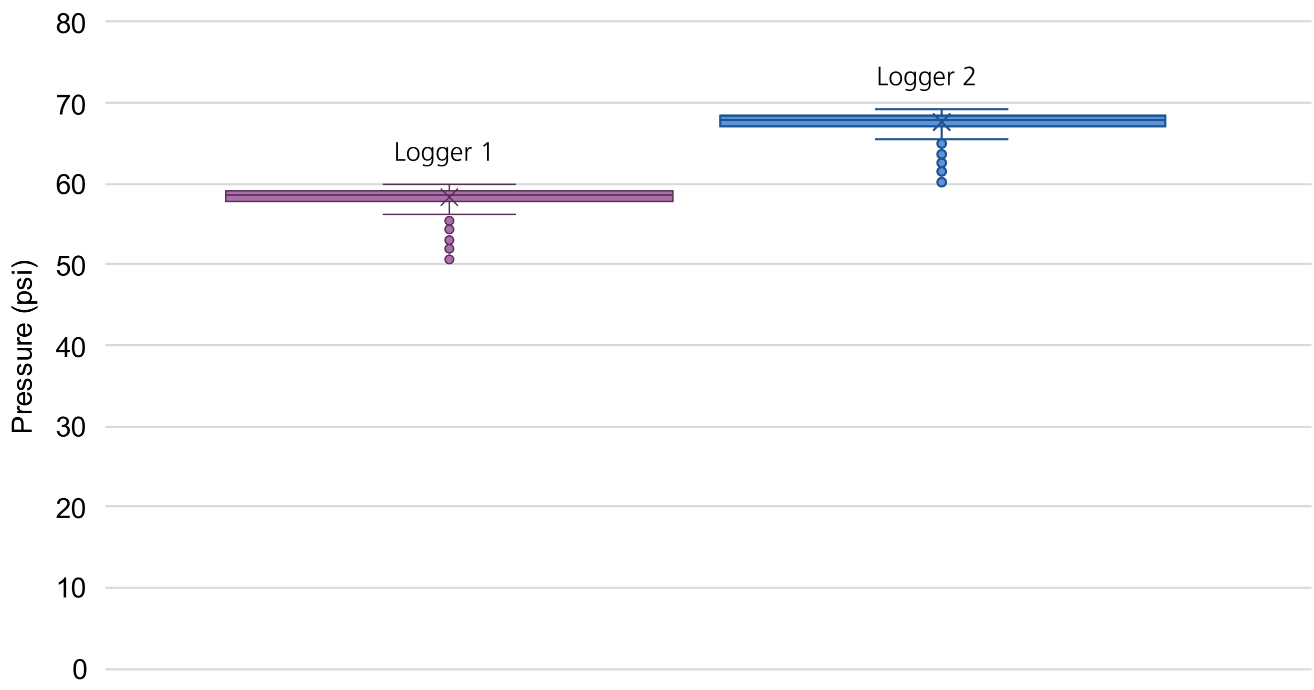
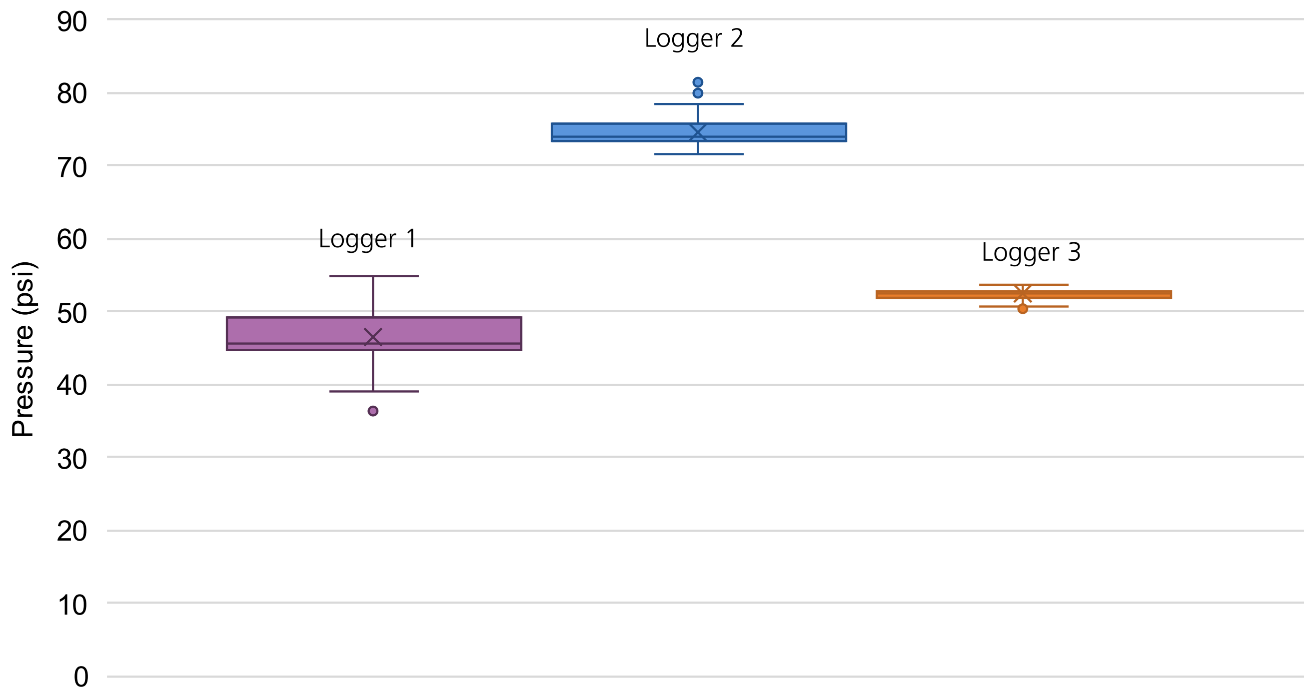


Figure 8-4: Boundary Pressure Loggers



8.2 FLOW TESTS

In addition to continuous pressure logging, 14 flow tests were conducted to record how the system pressures respond to high flows. For each flow test, one or two hydrants were opened (flow hydrant) and allowed to flow while the pressure was measured at a nearby hydrant (residual test hydrant). These tests measured localized distribution system responses to various demands, which were used to help determine the C-value.

The flow at each hydrant was the calculated using the coefficient of discharge (C_d), outlet diameter (d), and pitot pressure (p) using the following equation:

$$Q = (29.83 * C_d * d^2 * p^{0.5})$$

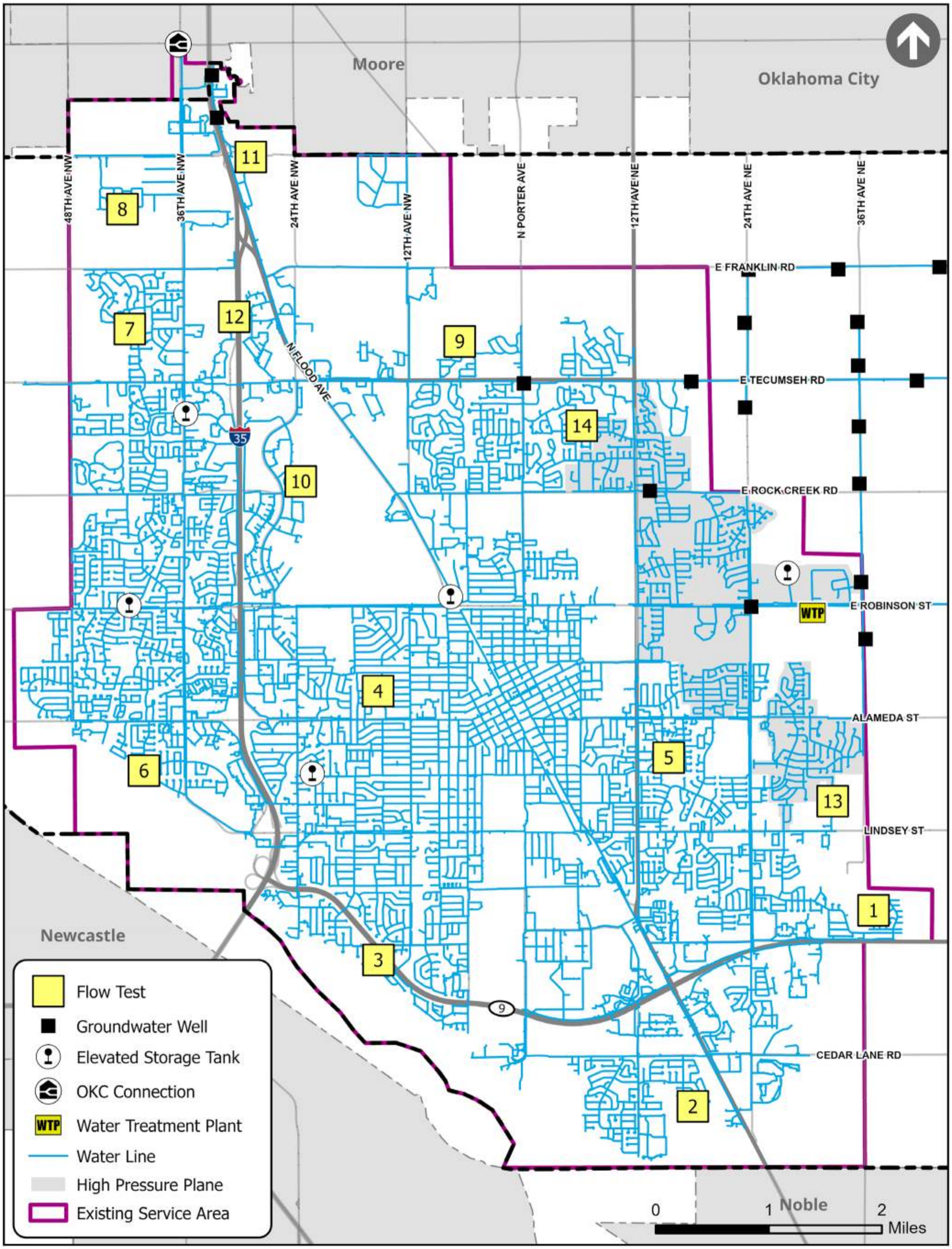
Table 8-2 contains the data collected during the flow tests and calculated flow values. Map 8-2 shows the locations of the 14 different flow tests performed.

Table 8-2: Flow Tests Summary

Flow Test	Flow Hydrant			Residual Hydrant			
	Flow Hydrant ID	Elevation (ft)	Flow (gpm)	Residual Hydrant ID	Elevation (ft)	Static (psi)	Residual (psi)
1A	59441	1,157.3	1,271	35045	1,162.8	57	51
1B	59434	1,165.2	2,195	35045	1,162.8	57	43
2	65535	1,152.4	1,157	65564	1,152.3	64	56
3	16923	1,112.8	1,292	16935	1,104.5	84	72
4A	14439	1,153.5	1,157	15109	1,153.8	61	59
4B	14947	1,155.5	1,685	15109	1,153.8	61	57

Flow Test	Flow Hydrant			Residual Hydrant			
	Flow Hydrant ID	Elevation (ft)	Flow (gpm)	Residual Hydrant ID	Elevation (ft)	Static (psi)	Residual (psi)
5A	15835	1,177.0	1,059	15950	1,172.5	54	52
5B	15905	1,173.5	1,752	15950	1,172.5	54	47
6A	15944	1,120.4	1,230	15904	1,129.4	74	68
6B	15921	1,112.5	1,872	15904	1,129.4	74	59
7	63631	1,187.6	1,006	12809	1,187.3	48	45
8	32205	1,187.8	1,018	32204	1,185.8	50	42
9A	18970	1,120.8	1,390	18994	1,121.3	78	75
9B	18990	1,119.4	2,582	18994	1,121.3	78	68
10	18637	1,177.4	1,148	18638	1,177.0	52	50
11	12637	1,157.0	1,175	12638	1,169.4	56	51
12	50434	1,171.7	1,172	17369	1,171.8	54	51
13	17716	1,205.5	1,092	17717	1,210.7	64	47
14	13239	1,177.9	1,195	13247	1,184.0	77	58

Map 8-2: Flow Test Overview



9.0 MODEL CALIBRATION AND VALIDATION

9.1 PRESSURE MONITORING VALIDATION

Garver compared extended period simulation results from the model under average day conditions with field data from historical SCADA and pressure logger data on April 11, 2024, as shown in Figure 9-1 and Figure 9-2. As shown in the figures, the model results are within a few feet/psi of the field data, which is within the range that will generally not impact system-wide pressure and velocity results under average and maximum day conditions. However, the model generally appears to underpredict head losses between the Vernon Campbell WTP and the ESTs in the MPP, as indicated by the lower Vernon Campbell WTP discharge pressures predicted in the model at high flow rates. A backwash cycle occurred at approximately 1:30 PM on April 11, which is indicated by the short dip in pressures and flow from the Vernon Campbell WTP.

Figure 9-1: April 11th SCADA Tank Level Comparison with Model Results

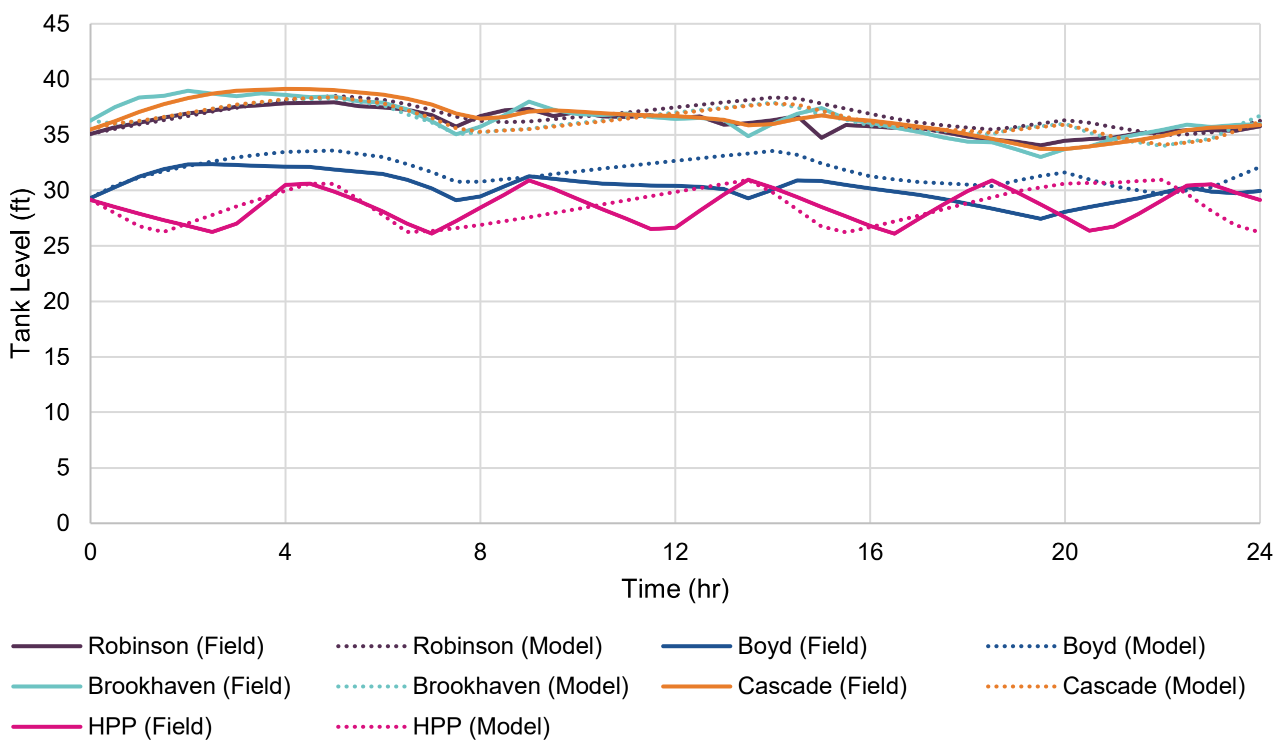
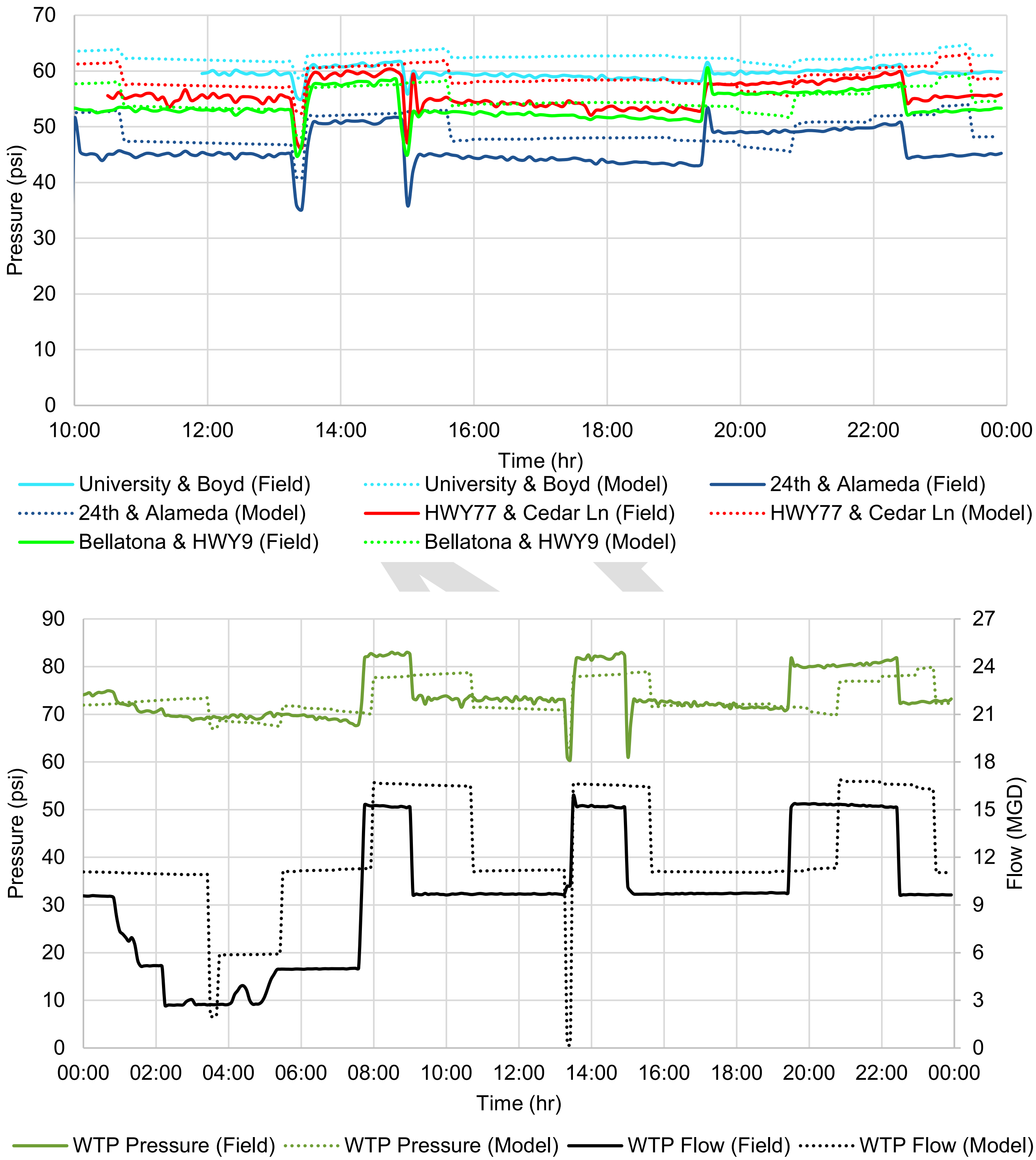


Figure 9-2: April 11th Pressure Logger Comparison with Model Results



9.2 FLOW TEST VALIDATION AND CALIBRATION

Garver also compared the pressure logger data and pressure gauge measurements taken during the flow tests to model results under the same conditions. A static (no hydrant flow) pressure scenario was created for each flow test to model the conditions prior to each test. A flow test scenario was also created for each test to include the hydrant flow as a point demand in the model. Model pressures were obtained for each static pressure and flow test scenario at the model junctions corresponding to the hydrants used for pressure measurements (test hydrants).

Figure 9-3 and Figure 9-4 show the calibration results for static pressures and pressure drops, respectively. In both figures, results measured in the field are plotted along the horizontal axis for each location, while the results calculated in the model are plotted along the vertical axis. The data point labels include the flow test number followed by lettering (A, B, etc.) for different flow rates at the location. Perfect agreement between the field measurements and model results is represented by points that fall directly on top of the thick black 1:1 line in the figures. A range of ± 5 psi is shown within the gray dashed lines on Figure 9-3 to account for the anticipated level of precision for static pressures, which depends on agreement between the elevation data (used in the model) and pressure gauge measurement (for field values). Additionally, a range of ± 2 psi or ± 10% (whichever is greater) of the measured pressure drop is shown within the gray dashed lines on Figure 9-4 to account for the anticipated level of precision for pressure drops.

The results presented in Figure 9-3 and Figure 9-4 are following corrections for the GIS pipe connectivity issues. As discussed in Section 7.2, the model C-values are consistent with those used in the 2018 Modeling Update Report. The model pressure drops are generally higher than the field pressure drops, which is preferable for producing conservative model results. The model pressure drops that are above the target agreement range in the MPP are in areas near cast iron pipes with C-values of 100 to 110 (Flow Tests 3, 4, and 7). Since cast iron corrosion can be unpredictable, maintaining the C-values of 100 to 110 supplies a more conservative approach compared to increasing the C-value for cast iron to improve agreement with the field pressures drops in these areas.

For the HPP Flow Tests 13 and 14, the model pressure drops were both significantly higher than the pressure drops observed in the field. Similar issues with model calibration in the HPP were discussed in the 2018 Modeling Update Report. Most of the head losses in the model flow test scenarios occur in 6-inch pipes near the flow hydrants with C-values of 140 or above, so increasing these C-values within the typical range would not result in agreement within the target range. It is more likely that there are differences between pipe diameters, pipe connectivity, and/or zone boundary conditions between the model and the field.

Figure 9-3: Flow Test Static Pressure Comparison with Model Results

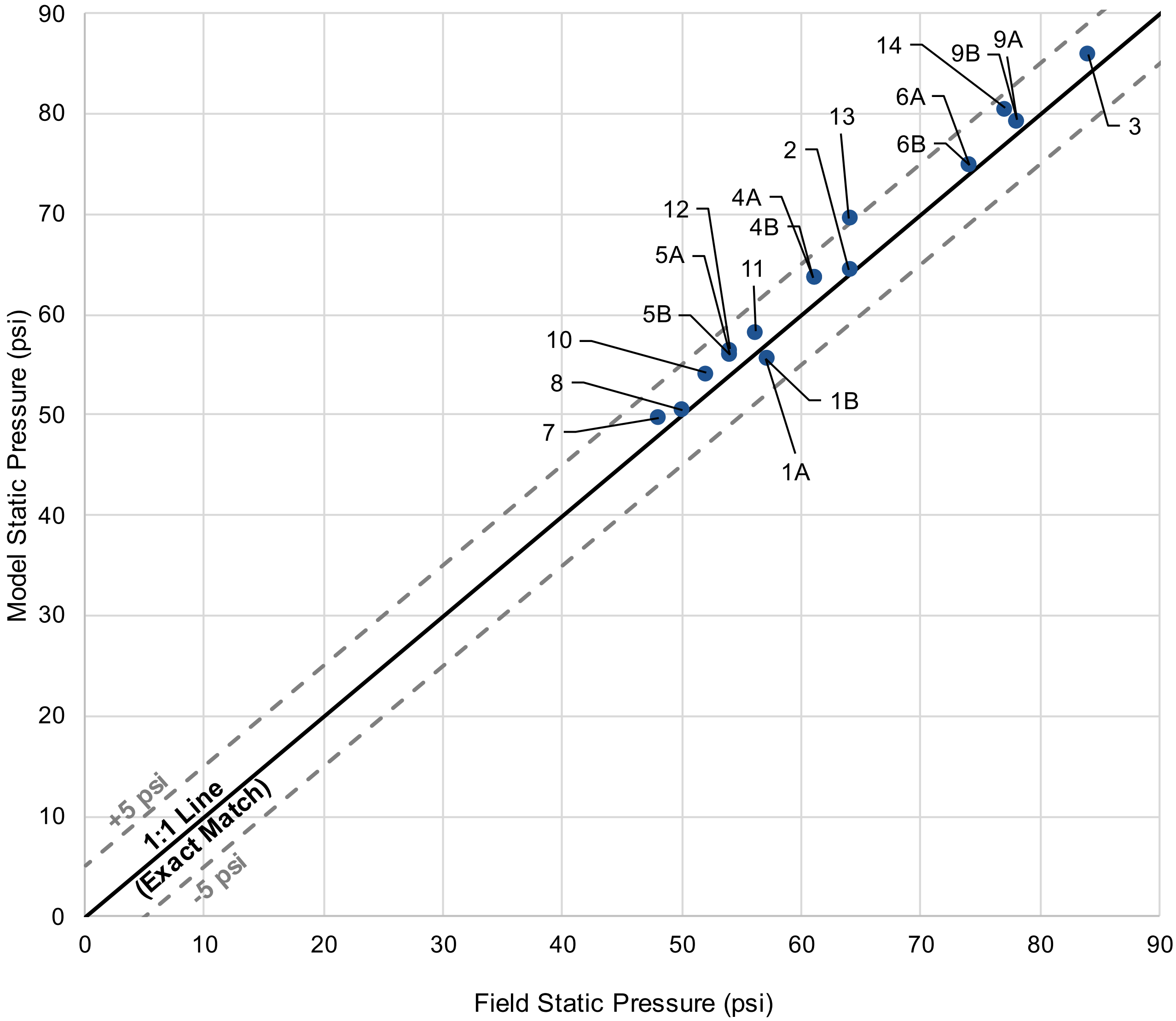
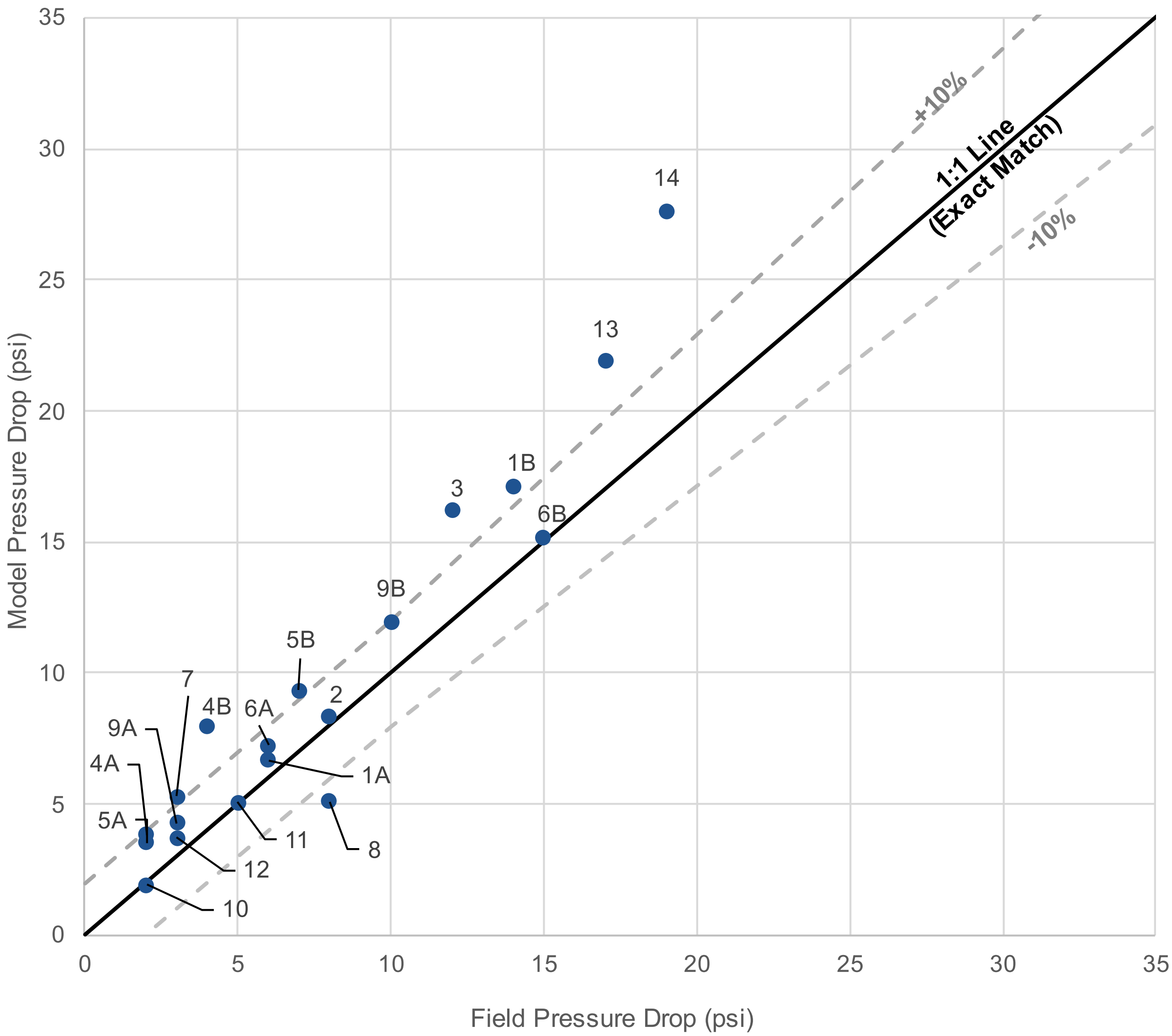


Figure 9-4: Flow Test Pressure Drop Comparison with Model Results



10.0 EXISTING SYSTEM ASSESSMENT

The evaluation criteria for the existing system assessment were presented in Table 6-1. The following sections describe the assessments for each component of the NUA distribution system.

10.1 SUPPLY CAPACITY ASSESSMENT

As discussed in Section 3.1, NUA uses three main sources for water supply: surface water, groundwater, and purchased water from OKC. The permitted amounts or the average and maximum capacities of each source are summarized in Table 10-1.

Table 10-1: Supply Capacity Summary

Source	Average Annual Capacity (MGD)	Maximum Day Capacity (MGD)
OKC	1.0	1.0
Groundwater	6.5	12.0
Surface Water	8.5	17.0
Total	16.0	30.0

Figure 10-1 and Figure 10-2 compares the projected ADD and MDD discussed in Sections 3.5 to the current capacities of each source between 2025 and 2050. Without the availability of flood pool supply from Lake Thunderbird, NUA would be unable to supply the projected ADD (excluding the reserve capacity) with the current sources of supply by approximately 2030. Similarly, NUA may be unable to supply MDD (excluding the reserve capacity) during hot and dry summer conditions without new sources of supply or watering restrictions by 2025.

Figure 10-1: Projected Average Day Demand Supply Gap

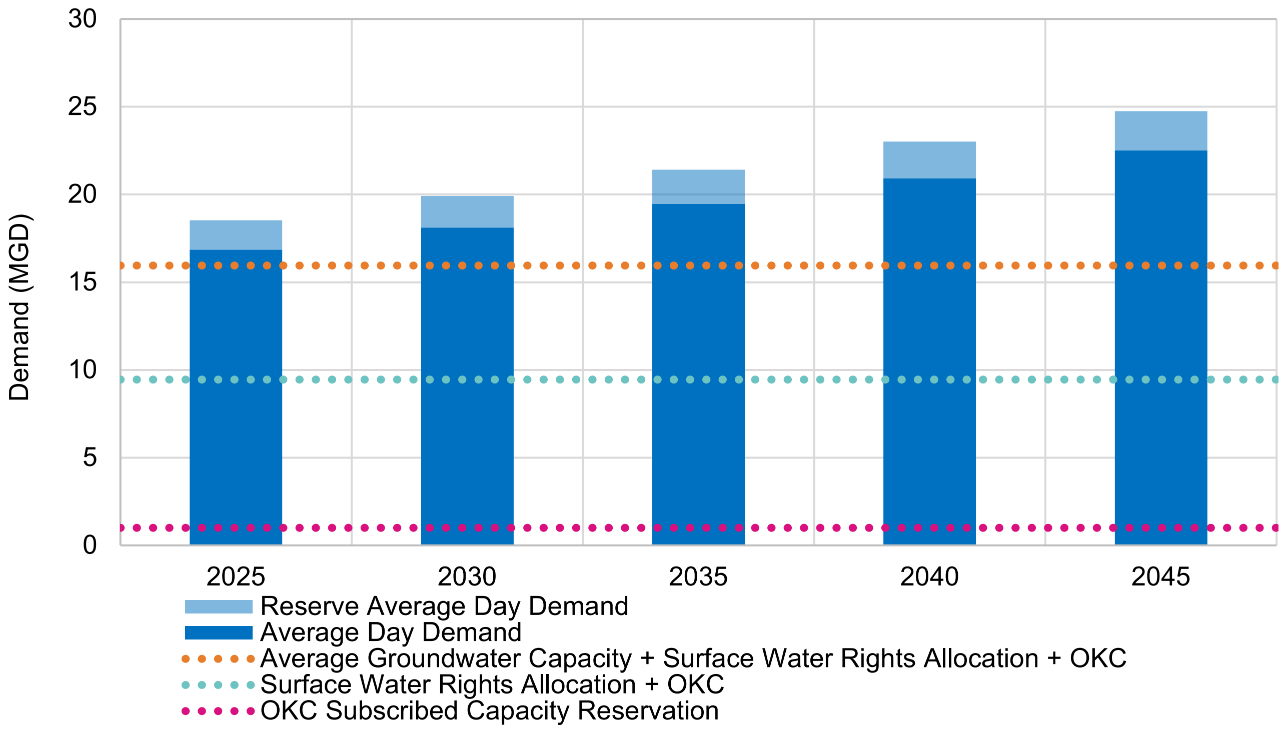
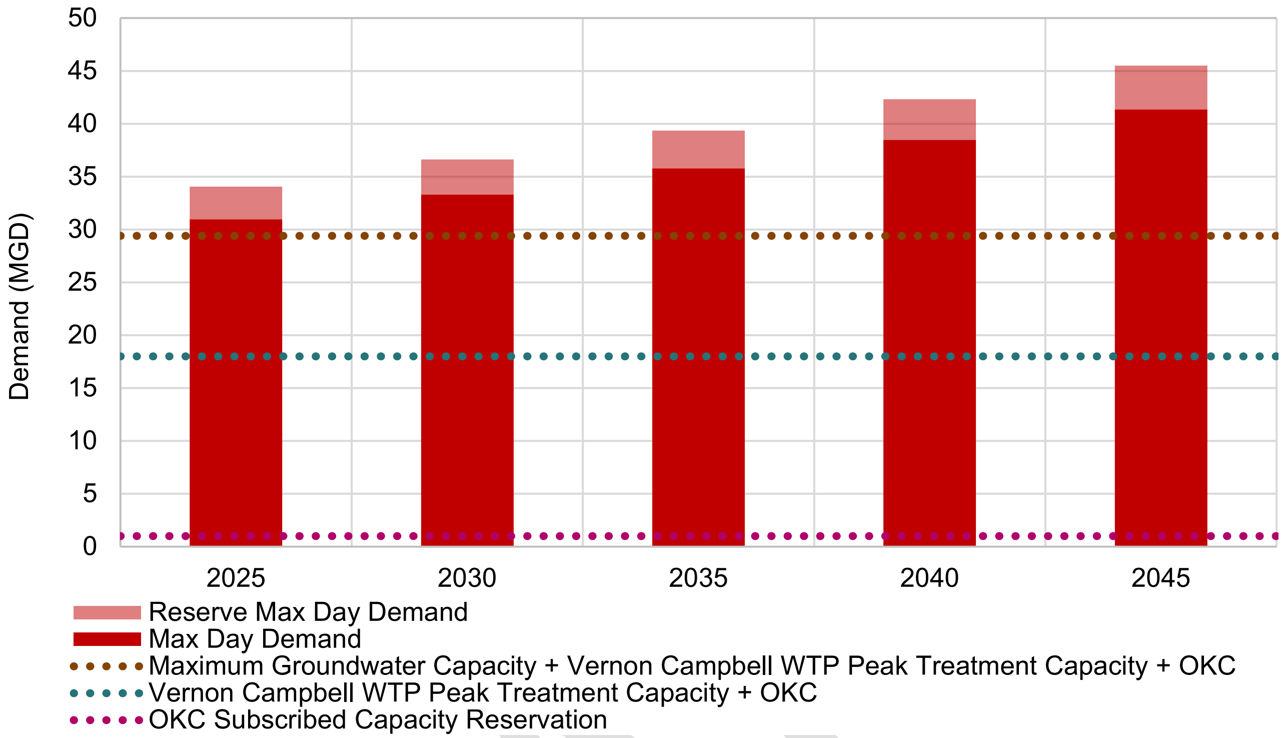


Figure 10-2: Projected Maximum Day Demand Source Supply Gap



Water from Lake Thunderbird is allocated based on the permitted withdrawal of the reservoir. Various studies have been completed by the BOR have determine a more sustainable annual withdrawal. Results from the firm yield modeling of Lake Thunderbird have been lower than the permitted yield, so there is a potential risk of the permitted rights being reduced in the future.

Several reduced values have been discussed based on the results of these studies. The lowest of these values being 12,700 acre feet per year (AFY), which is used for the purpose of this analysis. This correlates to about 11.3 MGD across all permitted users. These studies related to the firm yield of Lake Thunderbird are discussed further in Section 11.2.1.1.

Under these conditions the percentage to each of the three municipalities that have water rights to Lake Thunderbird would not change, so NUA would only receive 43.8% of the total firm yield or 1,814 MG annually (4.97 MGD). This is roughly a 41% reduction from their normal permitted allotment from the reservoir. The existing permitted withdrawal and the anticipated future firm yield of Lake Thunderbird are shown in Table 10-2.

This potential decrease in surface water allotment increases the project supply gap discussed above. Additional conservation measures within NUA could be used to help minimize this supply gap during these periods. If these conditions were to arise, it is anticipated that there will be approximately an average day supply gap of 12.3 MGD and a maximum day supply gap of about 28.1 MGD by 2045. The projected average and maximum day demand with this firm yield are shown in Figure 10-3 and Figure 10-4, respectively.

Table 10-2: Lake Thunderbird Water Rights

	Annual Volume (AFY)	Annual Volume (MG)	Annual Daily Volume (MGD)
Existing Permitted Withdrawal	9,522	3,103	8.5
Potential Future Firm Yield	5,562	1,814	5.0

Figure 10-3: Projected Average Day Demand Supply Gap with Reduced Firm Yield

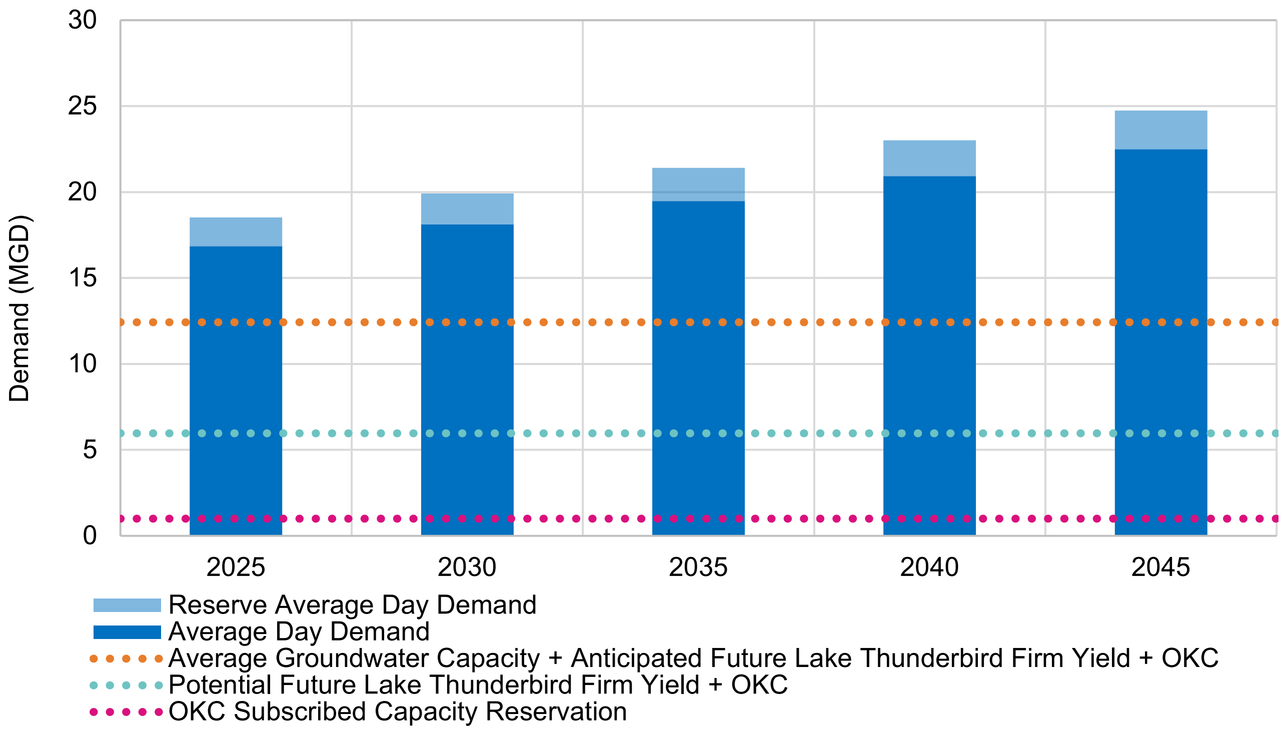
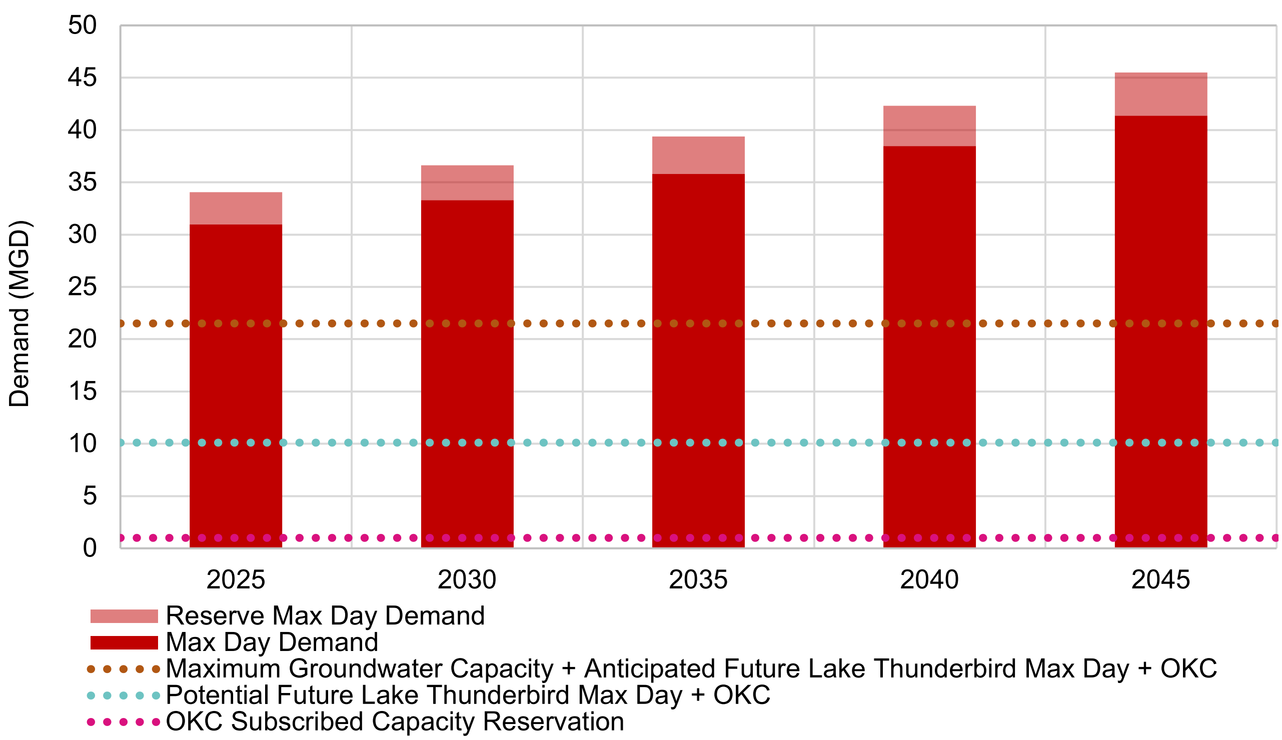


Figure 10-4: Projected Maximum Day Demand Supply Gap with Reduced Firm Yield



10.2 STORAGE CAPACITY ASSESSMENT

The NUA distribution system includes five ESTs within the MPP, ranging in volume between 0.5 and 2.0 MG, and one 1.0 MG tank within the HPP. The low water level in each of the ESTs is above the water level elevation required to maintain service pressures in the distribution system, so the entire volume of each tank can be used during emergencies.

There are also two clearwells located at the Vernon Campbell WTP with a total storage volume of 7.5 MG that can supply water via the existing pump station to both pressure planes.

ODEQ requires sufficient storage capacity to meet domestic demands and fire flow demands over a 24-hour period while maintaining 25 psi throughout the distribution system. The hydraulic model results discussed in Section 10.4 show that there is adequate elevated storage in the distribution system to maintain pressures above the ODEQ requirement during peak demand periods. Garver verified that the storage in each pressure plane also exceeds the fire flow storage required per Appendix B of the IFC.

Garver also compared the NUA storage capacity to typical water industry target values to evaluate whether additional storage may improve operations and/or mitigate risks during emergencies. Many water utilities target a total storage volume equal to one day at ADD to mitigate the risks of supply interruptions. For elevated storage, a volume of at least 10% of MDD would yield adequate equalizing storage for periods when peak demands exceed the supply capacity. The target storage volume is typically double the equalizing storage to account for operational and emergency storage, so the total elevated storage capacity is approximately 20% of the MDD. This value is consistent with other systems in the region with similar diurnal curve patterns. Table 10-3 summarizes the comparison between the existing storage capacity and typical industry targets. Additional elevated storage will be needed to meet the elevated storage capacity target in the MPP. The total storage capacity is lower than one day of ADD; however, the chances of total supply interruption for the NUA system is lower than for most systems because the system has multiple sources of supply. Additional elevated storage will likely be needed in the MPP as the system expands and the difference between peak hour demands and supply capacity increases.

Table 10-2: Existing Storage Assessment

Pressure Plane/ Overall System	Tanks	Total Storage (MG)	Available Storage[1] (MG)	Total Available Storage (MG)	Typical Storage Target[1] (MG)	Difference (MG)
MPP	Boyd Tower	0.5	0.5	4.5	6.2	(1.7)
	Brookhaven Tower	1.5	1.5			
	Cascade Tower	2.0	2.0			
	Robinson Tower	0.5	0.5			
HPP	PZ Tower	1.0	1.0	1.0	0.3	0.7
Overall Water System	6.5-MG Clearwell	6.5	6.5	7.5	--	--
	1.0-MG Clearwell	1.0	1.0			
Overall Water System Total		13.0	13.0	13.0	18.6	(5.6)

Notes:
1. Based on typical industry storage capacity targets of one day of ADD for total storage and 20% of MDD for elevated storage.

10.3 PUMPING CAPACITY ASSESSMENT

NUA currently operates two pump stations located at the Vernon Campbell WTP that pump treated surface water into the distribution system. A summary of the existing pumps in the NUA distribution system is supplied in Table 10-3.

Table 10-3: Existing Pumping Facility Summary

Plane	Pump	Design Capacity (gpm)	Horsepower (hp)
MPP	1	3,500	250
	2	3,500	250
	3	3,500	250
	4	3,500	250
HPP	1	1,563	100
	2	1,563	100
	3	1,563	100

The existing MPP Pump Station has a total combined capacity of 20.2 MGD with a firm capacity of 15.1 MGD. The MPP is supplied by all three available sources, and under standard conditions the existing pumps can meet MDD with all pumps operating. The firm capacity of the existing MPP Pump Station is not adequate to meet MDD that could occur during a hot and dry summer. However, the HPP has excess pumping capacity that could be used to supply the MPP. Additionally, increasing the supply from groundwater and OKC would reduce pumping requirements for the MPP.

Currently, the HPP is only supplied by the Vernon Campbell WTP via a nearby pump station. The HPP Pump Station has a total combined capacity of 6.8 MGD with a firm capacity of 4.5 MGD, as shown in Table 10-4. The firm capacity of the existing HPP Pump Station is adequate to meet MDD.

Table 10-4: Existing Pumping Facility Summary

Plane	Max Day Demand[1] (MGD)	Total Capacity (MGD)	Firm Capacity (MGD)
MPP	18.2	20.2	15.1
HPP	2.9	6.8	4.5

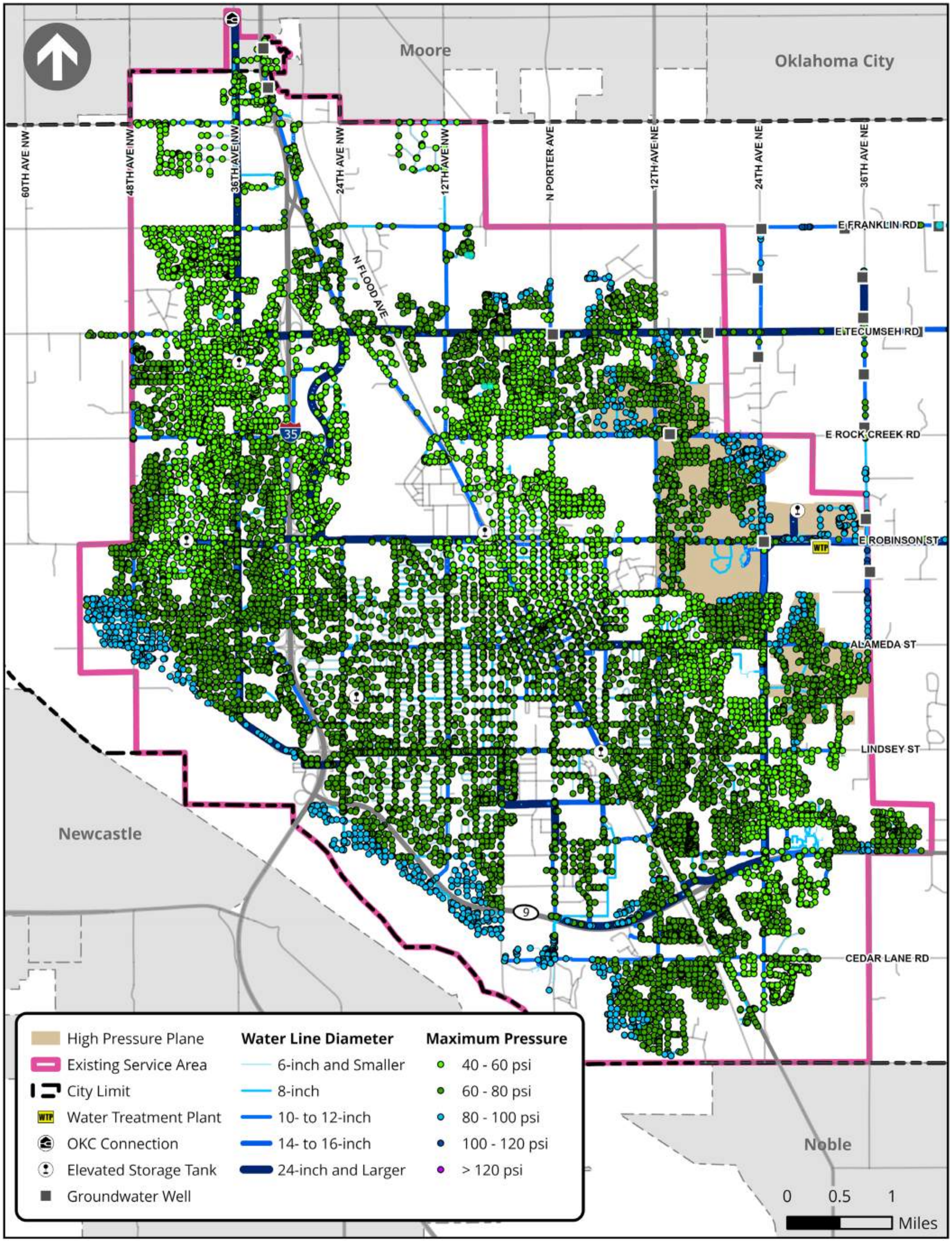
Notes:
1. Demand values presented do not include the demand supplied by other available sources within the given pressure plane.

10.4 HYDRAULIC MODEL RESULTS

10.4.1 AVERAGE PRESSURE

The maximum pressure results within the extent of the WSA for the 2025 ADD scenario are shown in Map 10-1. Most of the NUA distribution system experiences an average pressure ranging between 45 and100 psi. There are no pressure results greater than 100 psi within the WSA, but there are pressures between 100 and 120 psi in the far northeastern portion of the system.

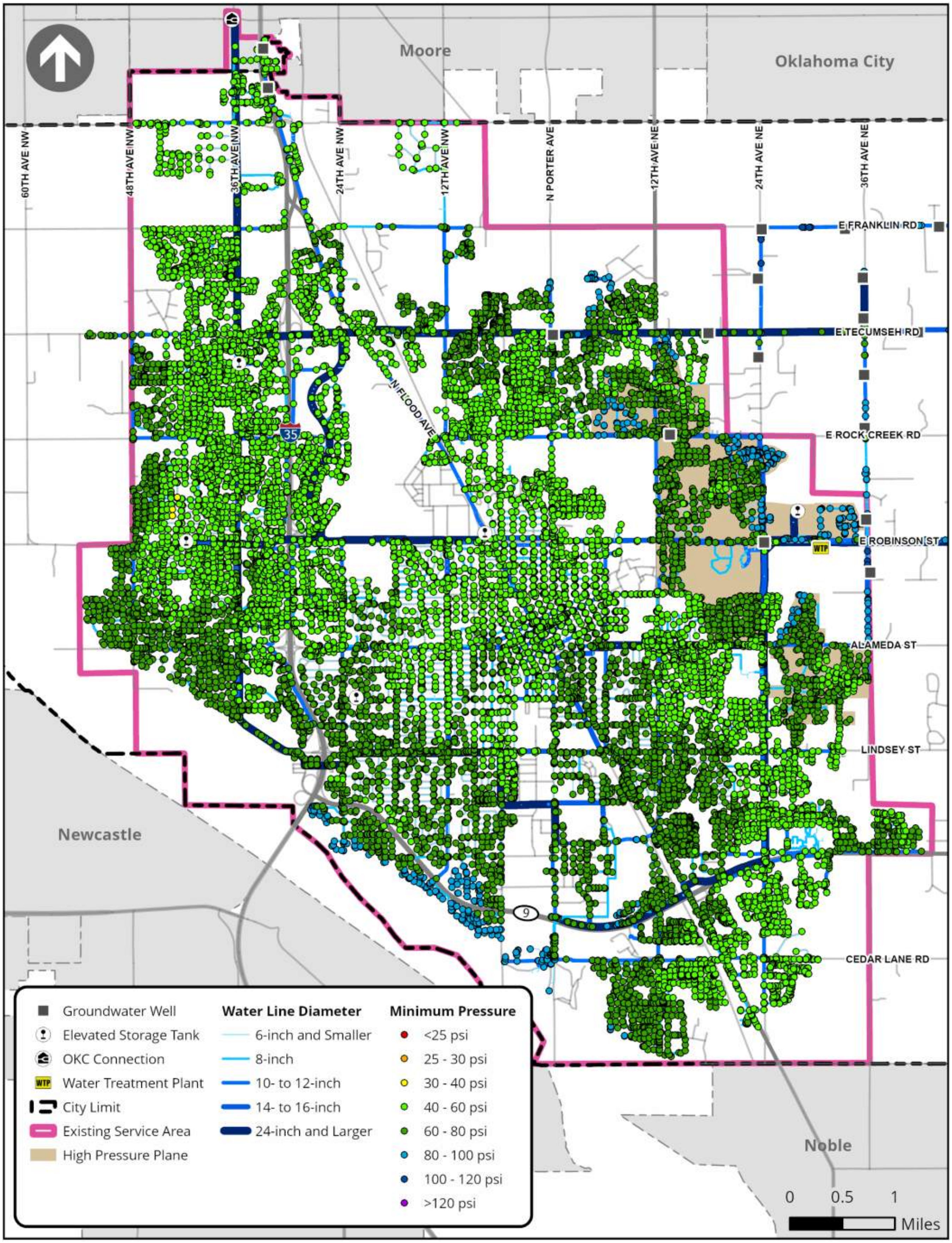
Map 10-1: Existing System Maximum Pressure Results



10.4.2 MINIMUM PRESSURE

The minimum pressure results within the extent of the WSA for the 2025 MDD scenario are shown in Map 10-2. Minimum pressures within the WSA generally range between 40 and 80 psi.

Map 10-2: Existing System Minimum Pressure Results



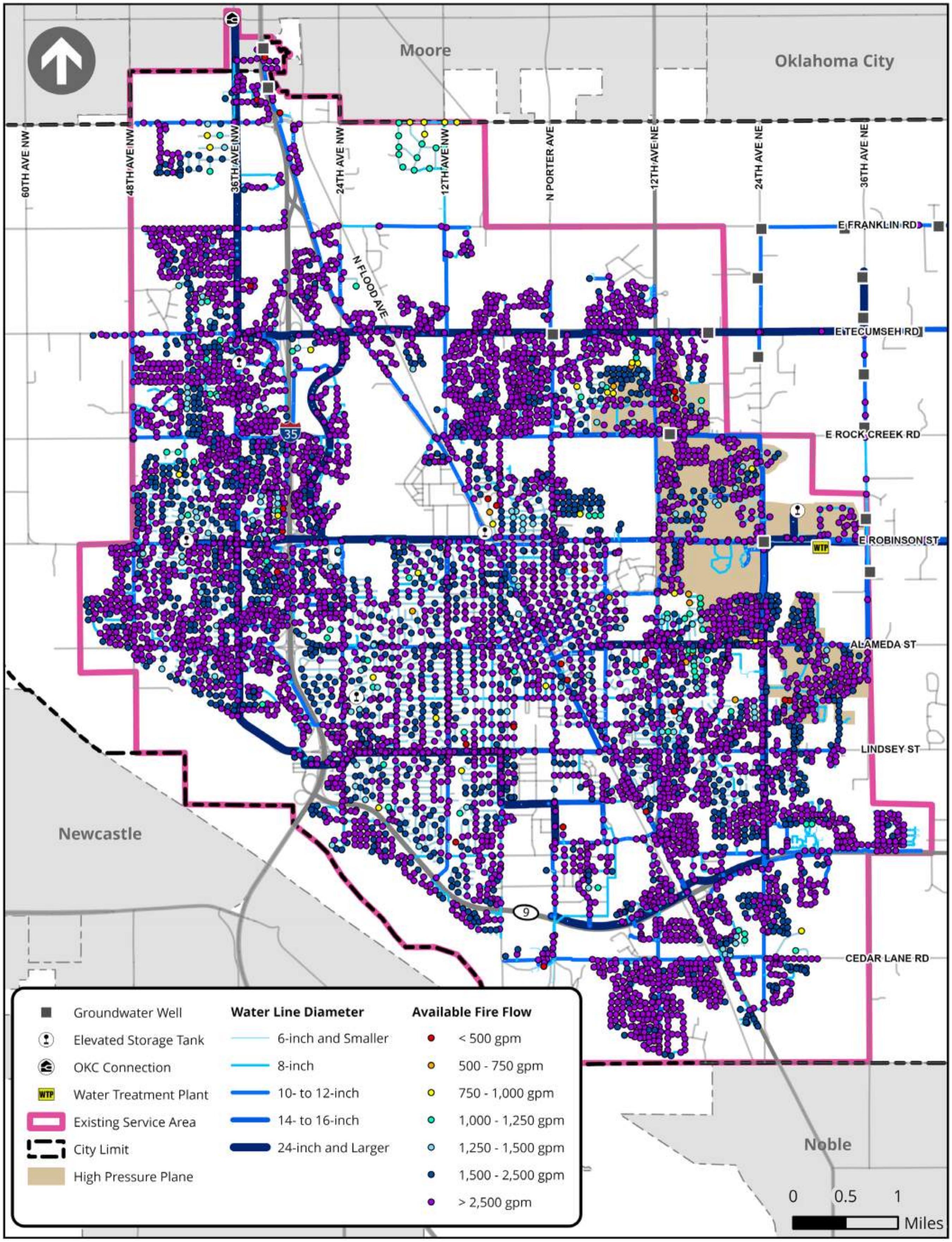
10.4.3 FIRE FLOW

The available fire flow results for the 2025 fire flow scenario are shown in Map 10-3. The typical fire flow requirement per the 2018 IFC is 1,000 gpm for residential areas, while commercial fire flow requirements are site-specific but are typically 1,500 gpm or greater. The NUA target level of service is 1,500 gpm for all points in the service area.

The model results show available fire flow throughout most of the distribution system to be greater than 1,500 gpm along 8-inch and larger water lines. The following areas experience available fire flow values below 1,500 gpm:

- The area near West Indian Hills Road and 12th Avenue Northwest
- The area near West Indian Hills Road and 36th Avenue Northwest
- The northern portion of the HPP
- The area south of the boundary the MPP and HPP
- The neighborhood northeast of Cedar Lane and Highway 77

Map 10-3: Existing System Fire Flow Results

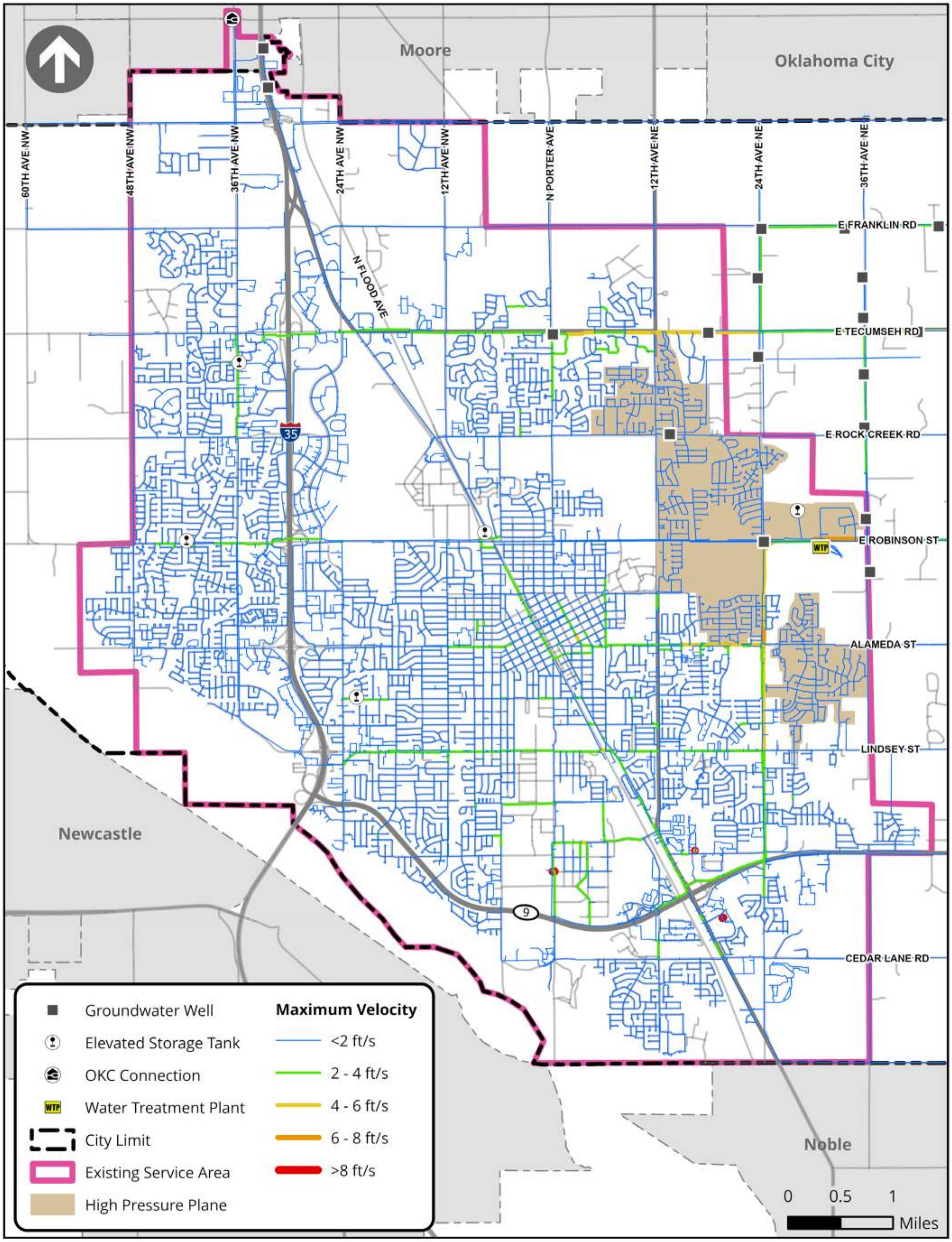


10.4.4 PIPE VELOCITY

The maximum flow velocity results within the extent of the WSA for the 2025 MDD scenario are shown in Map 10-4. Velocities are generally less than 2 ft/s through most of the WSA except for select transmission mains from the groundwater wells in the eastern portion of the system and select transmission mains downstream of the Vernon Campbell WTP which range between 4 and 6 ft/s. The following area experience a maximum velocity greater than 6 ft/s:

- The 30-inch transmission line along Alameda Street from 24th Avenue Northeast to Newman Street
- The 6-inch water line connecting two 12-inch water lines along South Jenkins Avenue

Map 10-4: Existing System Pipe Velocity Results



10.4.5 HEAD LOSS GRADIENT

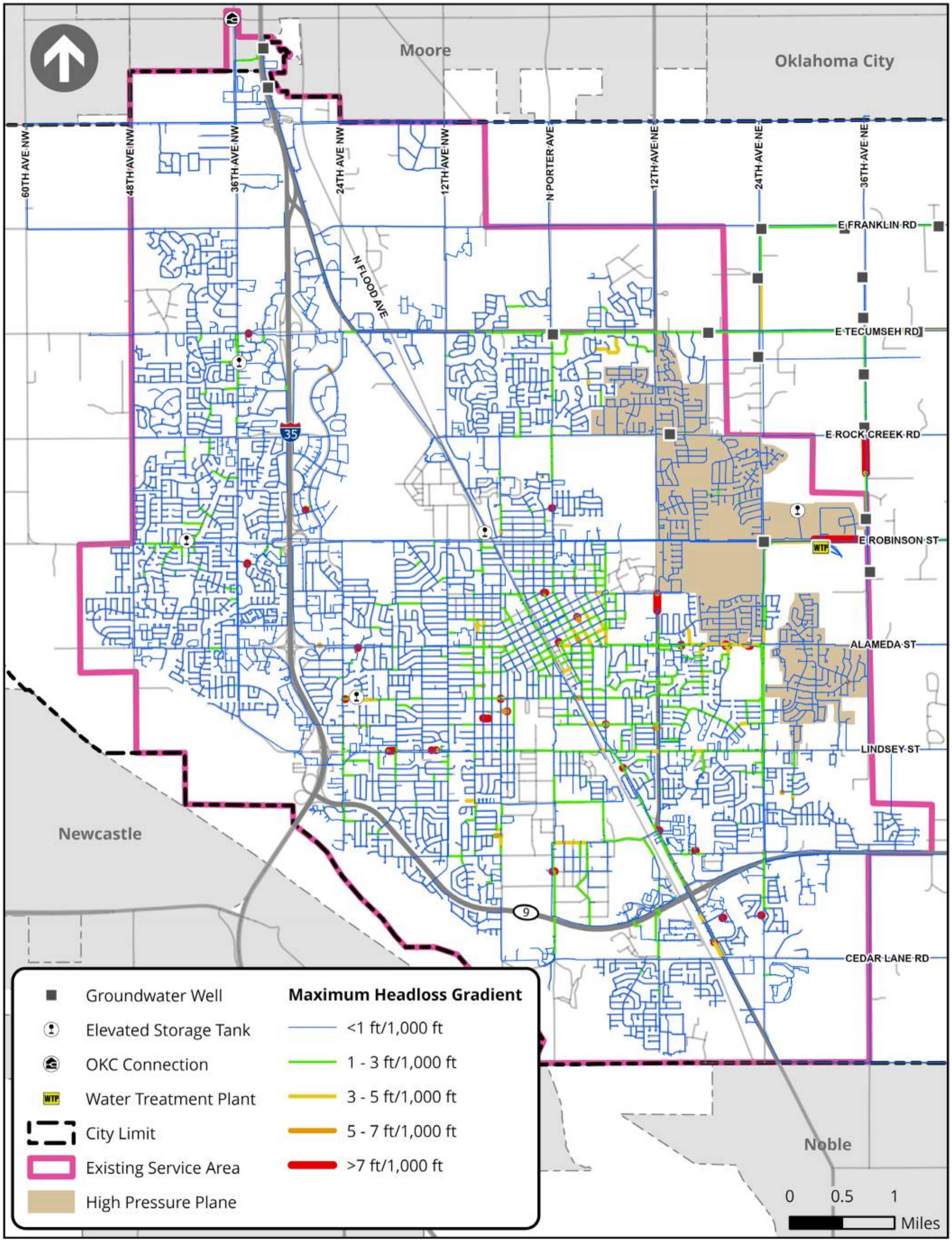
The maximum head loss gradient results within the extent of the WSA for the 2025 MDD scenario are shown in Map 10-5. These results can be used to identify pipe segments where additional looping or larger pipe diameters would reduce head losses. Maximum head loss gradients for smaller pipes (diameter < 16 inches) exceed 7 ft/1,000 ft in the following areas:

- The 8-inch water line south of East Robinson Street and 12th Avenue Northeast
- The 8-inch water line along Alameda between Crestland Drive and Vicksburg Avenue
- The 8-inch water line along 12th Avenue Northeast from East Main to Morren Drive
- Various small-diameter dead-end water lines throughout the system

Maximum head loss gradients for larger pipes (diameter ≥ 16 inches) exceed 3 ft/1,000 ft in the following areas:

- Select transmission mains from the groundwater wells in the eastern portion of the system

Map 10-5 : Existing System Head Loss Gradient Results

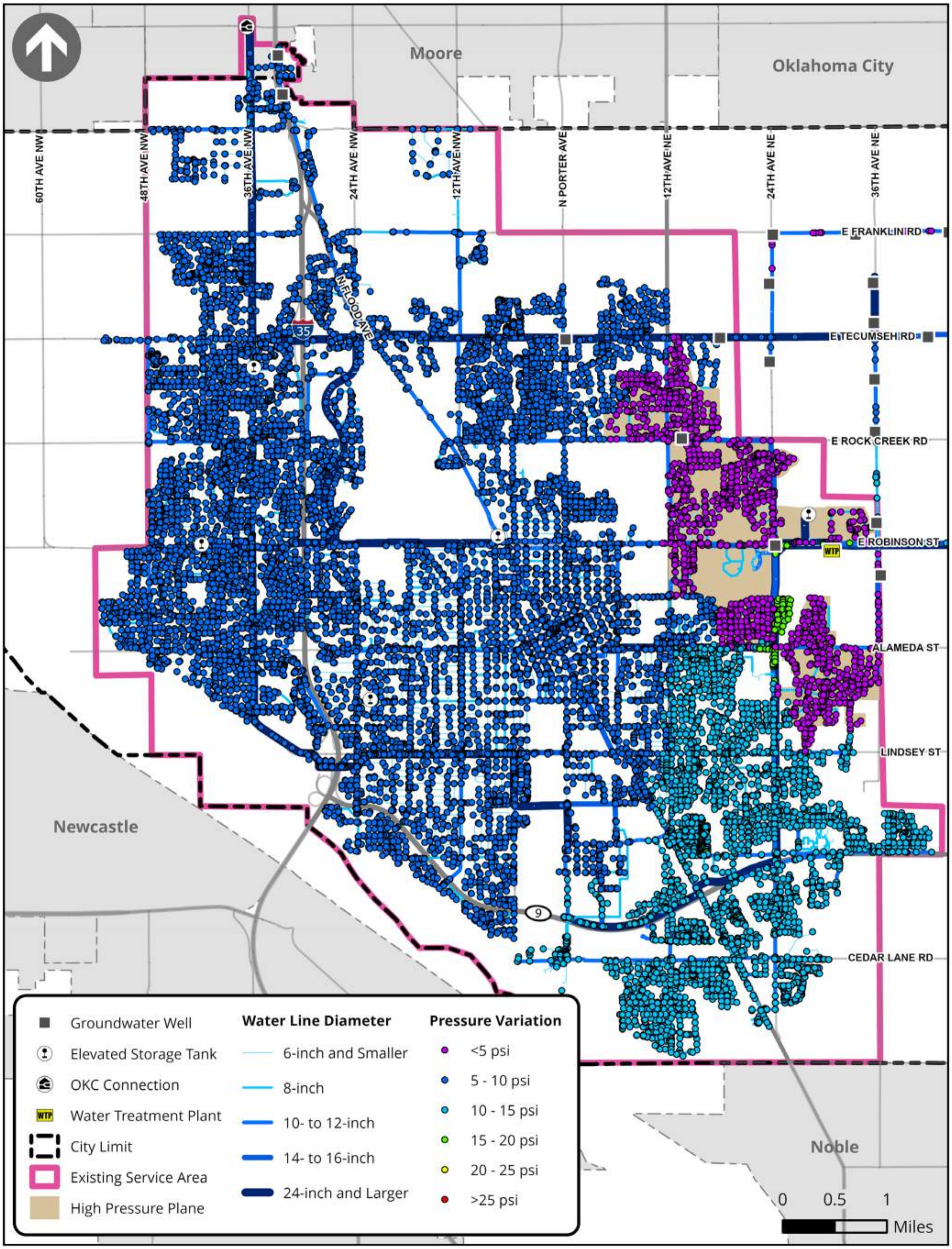


10.4.6 PRESSURE VARIATION

The pressure variation results within the extent of the WSA for the 2025 MDD scenario are presented in Map 10-6. These results show the difference between the maximum and minimum pressure at each location over the course of the day. Pressure variations increase with distance from ESTs and are caused by head losses between the ESTs and both pump stations and high demand areas. Undersized transmission mains increase the magnitude of the head losses and pressure variations resulting from the changes in flow.

While pressure variation is not regulated by ODEQ, excessive changes in pressure can impact water loss and customer satisfaction. Pressures within the HPP remain relatively constant, with variations of less than 5 psi. The eastern and central portion of the WSA experience a pressure variation of 5 to 10 psi. The southeastern portion of the system, south of the HPP boundary, experiences a pressure variation between 10 and 20 psi.

Map 10-6: Existing System Pressure Variation Results



10.5 SUMMARY OF EXISTING SYSTEM DEFICIENCIES

Table 10-5 summarizes the existing water system deficiencies described in the previous sections.

Table 10-5: Existing Water System Deficiencies

Criteria	System Deficiency
Supply	The current sources of supply are adequate to meet the existing MDD for years with hot and dry summer conditions; however, additional capacity will be needed to meet the projected MDD.
Pumping	The existing Vernon Campbell WTP pump stations have adequate total capacity to meet demands for each pressure plane. However, the firm capacity is less than the projected MDD in the MPP. However, the HPP has excess capacity that could be used to supply the MPP. Additional pump capacity may be required in the future if the Vernon Campbell WTP capacity is expanded.
Storage	Additional elevated storage will be needed in the MPP to provide equalizing storage capacity and support future growth. Additional emergency storage could also be considered but is less crucial given the system has multiple sources of supply.
Minimum Pressure	None. Minimum pressures exceed the ODEQ requirement of 25 psi. Pressures below the level of service target of 40 psi occur in isolated areas in the MPP and near the boundary with the HPP.
Fire Flow	Available fire flow is above the minimum requirement of 1,000 gpm in residential areas and 1,500 gpm in commercial areas, except at West Indian Hills Road and 12th Avenue Northwest. Available fire flow is below the level of service target of 1,500 gpm along 6-inch lines in multiple areas throughout the distribution system.
Maximum Flow Velocity (guideline)	Velocities are generally lower than 6 ft/s throughout the system, except for the 30-inch transmission mains near the Vernon Campbell WTP. The transmission mains from the wells have velocities in the 4–6 ft/s range, so additional transmission improvements may be required along with future increases in supply capacities.

11.0 WATER SUPPLY PLAN REVIEW

Garver completed a review and update of the 2060 Water Supply Plan. As part of this review, the water supply portfolios, screening methodology, cost estimates, and water supply alternative selection from the Water Supply Plan were updated. In the 10 years since the document was written, anticipated water availability of several sources has changed. Part of this update included updating sources where availability had changed to include the new anticipated supply volume. New supplies including Lake Thunderbird spillage, South Canadian alluvial wells, and stormwater capture were added. Garver then updated the cost estimates provided in the Water Supply Plan and developed a new methodology to determine the best alternatives to meet NUA's needs.

This section provides as an overview of the information presented in the 2060 Water Supply Plan, updates to the information originally presented, and any new recommendations. An excerpt of the 2060 Water Supply Plan containing screening and portfolio selection is provided in Appendix D.

11.1 2060 WATER SUPPLY PLAN SUMMARY

The 2060 Water Supply Plan was completed to evaluate multiple supply options that were available at the time to increase the NUA's supply. The purpose of this plan was to identify and discuss potential new or existing sources that could be used to meet NUA's projected 2060 demands. This section summarizes the work completed and discusses any changes to supply alternatives that have occurred since the document was written as part of the original document.

11.1.1 2060 WATER SUPPLY PLAN PROJECTED DEMANDS

The projections used for the 2060 Water Supply Plan and the projections completed by Garver for this report were previously presented in Section 4.2. The values only differed slightly between the two projections through the year 2060. The 2060 Water Supply Plan used 29.1 MGD and 55.3 MGD for their 2060 planning projections for ADD and MDD, respectively, while Garver used 30.7 MGD and 56.5 MGD for average and maximum day demands, respectively. Current projections for ADD and MDD through the year 2060 are shown in Figure 11-1 and Figure 11-2.

Figure 11-1: Projected Average Day Demand

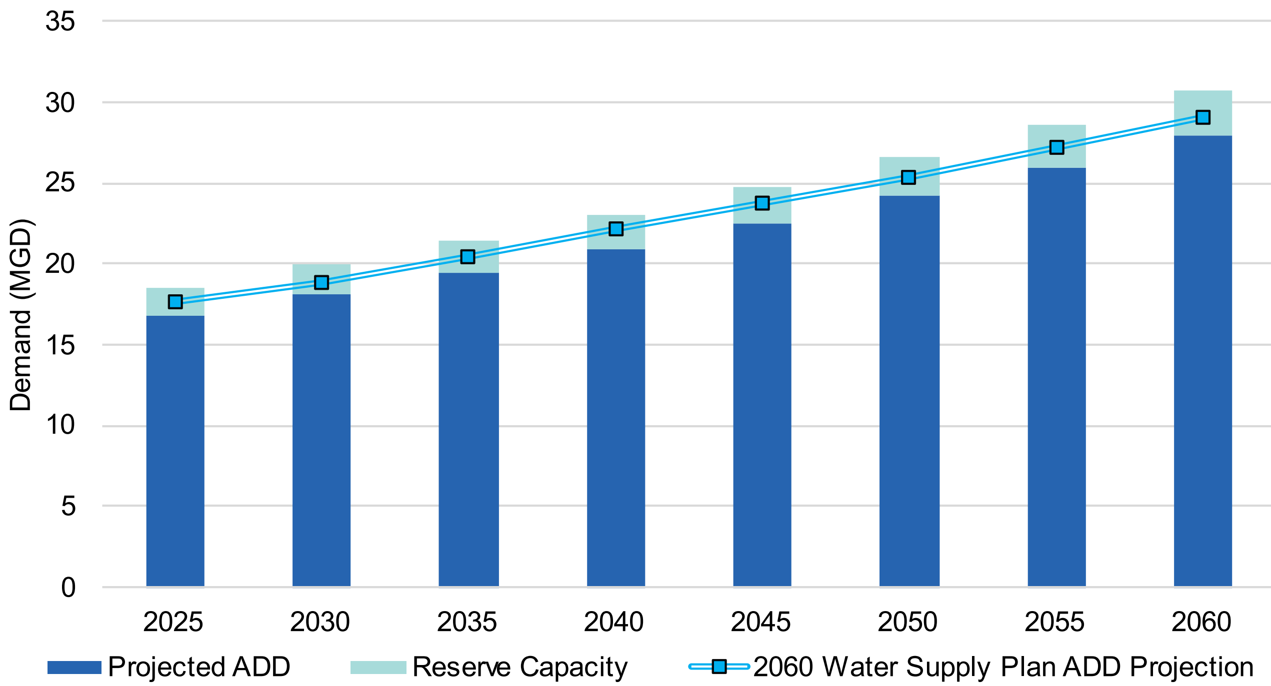
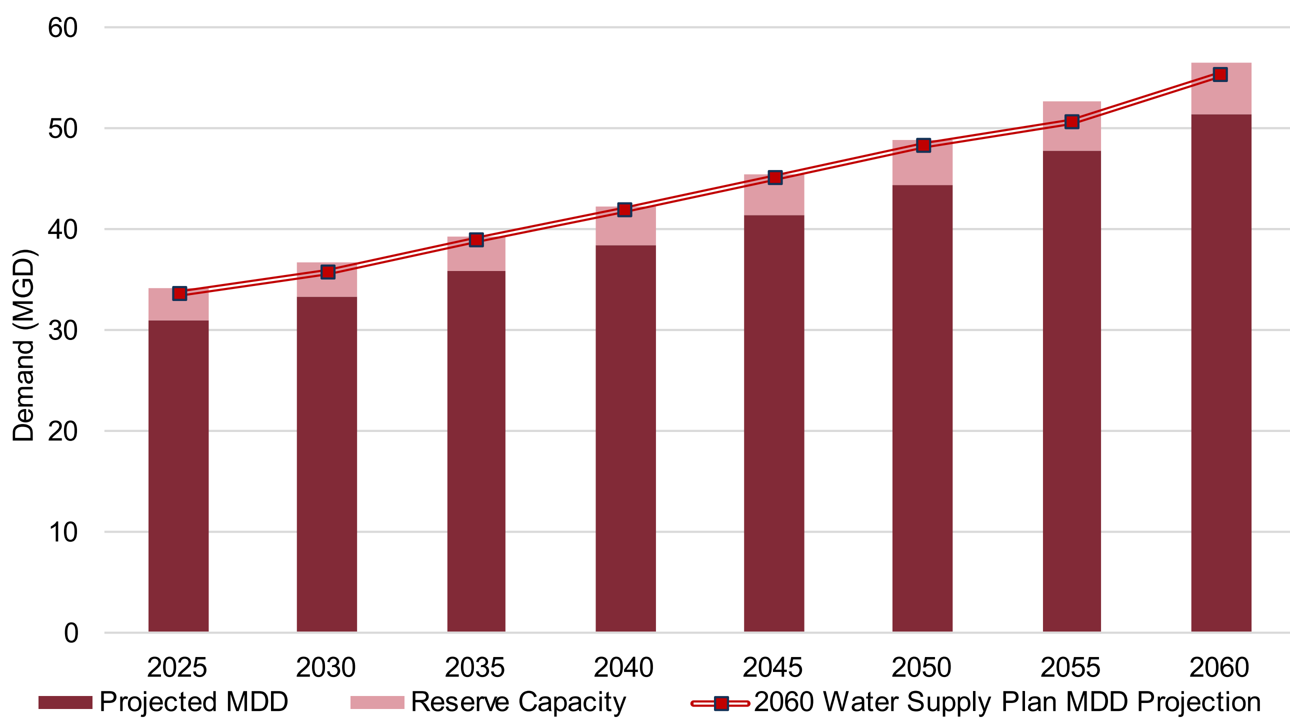


Figure 11-2: Projected Maximum Day Demand



11.1.2 2060 WATER SUPPLY PLAN WATER SUPPLY ALTERNATIVES

The 2060 Water Supply Plan developed several water supply portfolios based on preliminary screening that determined the viability of each supply alternative to meet the projected system demands. Key characteristics of each supply option analyzed include total available yield, firm yield, transmission distance, source reliability, possible implementation issues, capital cost, and unit cost. The following supply sources were selected for further analysis in the 2060 Water Supply Plan:

- Additional Conservation
- Garber-Wellington Groundwater Wells
- Lake Thunderbird
- Indirect Potable Reuse (IPR) via Lake Thunderbird Augmentation
- New Garber-Wellington Wells
- New In-Basin Reservoir
- New Out-of-Basin Reservoir
- Non-Potable Reuse
- Purchased Water from OKC

Following the preliminary screening of each source, 14 different water supply portfolios were created. Each portfolio was made up of a different combination of the listed sources and the necessary volumes for each to achieve average and maximum day demands. The sources and their respective volumes for average and maximum day demands for each of the portfolios are summarized in Table 11-1 and Table 11-2.

Table 11-1: 2060 Water Supply Plan Average Day Portfolio Summary

Portfolio Number	Supply by Source (MGD)											
	Lake Thunderbird	Active Garber-Wellington Wells	Inactive Garber-Wellington Wells	New Garber-Wellington Wells	Additional Conservation	Non-Potable Reuse	Lake Thunderbird Augmentation	Treated OKC (wholesale)	Treated OKC (co-owner)	Raw OKC (co-owner)	New Out-of-Basin Reservoir	New In-Basin Reservoir
1	6.1	6.0	2.1	--	1.0	0.8	13.1	--	--	--	--	--
2	6.1	6.0	2.1	--	1.0	0.8	--	13.1	--	--	--	--
3	--	--	--	--	--	--	--	--	29.1	--	--	--
4	--	--	--	--	--	--	--	--	--	29.1	--	--
5	--	--	--	--	--	--	--	--	--	--	29.1	
6	--	--	--	--	--	--	--	--	--	--	--	29.1
7	6.1	6.0	--	--	1.0	0.8	--	--	21.2	--	--	--
8	6.1	6.0	--	--	1.0	--	17.0	5.0	--	--	--	--
9	6.1	6.0	2.1	13.1	1.0	0.8	--	--	--	--	--	--
10	6.1	6.0	2.1	--	1.0	0.8	--	--	--	--	13.1	--
11	6.1	6.0	2.1	--	1.0	0.8	--	--	13.1	--	--	--
12	6.1	--	--	--	1.0	--	--	--	--	--	22.0	--
13	6.1	6.1	2.1	--	1.0	0.8	--	--	--	13.1	--	--
14	6.1	6.0	2.1	2.0	1.0	0.8	11.1	--	--	--	--	--

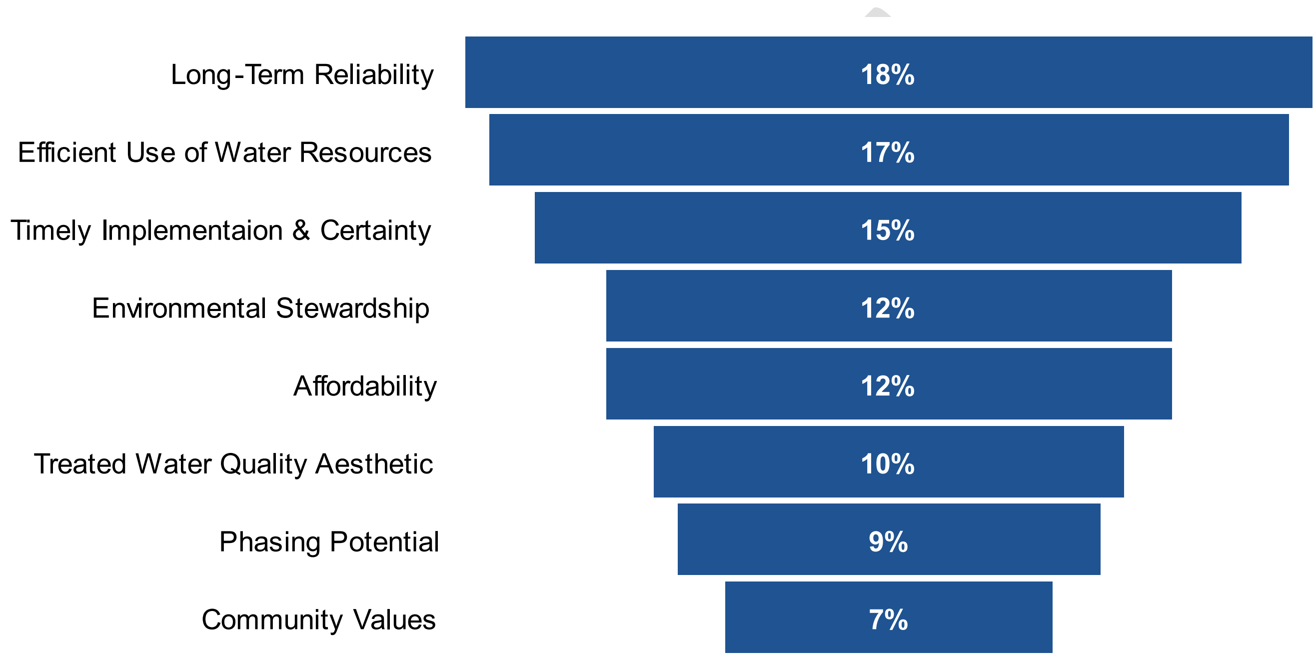
Table 11-2: 2060 Water Supply Plan Maximum Day Portfolio Summary

Portfolio Number	Supply by Source (MGD)											
	Lake Thunderbird	Active Garber-Wellington Wells	Inactive Garber-Wellington Wells	New Garber-Wellington Wells	Additional Conservation	Non-Potable Reuse	Lake Thunderbird Augmentation	Treated OKC (wholesale)	Treated OKC (co-owner)	Raw OKC (co-owner)	New Out-of-Basin Reservoir	New In-Basin Reservoir
1	17.0	9.0	2.7	--	1.5	4.6	20.5	--	--	--	--	--
2	17.0	9.0	2.7	--	1.5	4.6	--	20.5	--	--	--	--
3	--	--	--	--	--	--	--	--	55.3	--	--	--
4	--	--	--	--	--	--	--	--	--	55.3	--	--
5	--	--	--	--	--	--	--	--	--	--	55.3	--
6	--	--	--	--	--	--	--	--	--	--	--	55.3
7	17.0	--	--	--	1.5	4.6	--	--	32.2	--	--	--
8	17.0	--	--	--	1.5	--	29.3	7.5	--	--	--	--
9	17.0	9.0	2.7	20.5	1.5	4.6	--	--	--	--	--	--
10	17.0	9.0	2.7	--	1.5	4.6	--	--	--	--	20.5	--
11	17.0	9.0	2.7	--	1.5	4.6	--	--	20.5	--	--	--
12	17.0	--	--	--	1.5	--	--	--	--	--	36.8	--
13	17.0	9.0	2.7	--	1.5	4.6	--	--	--	20.5	--	--
14	17.0	9.0	2.7	3.0	1.5	4.6	17.5	--	--	--	--	--

11.1.3 2060 WATER SUPPLY PLAN PORTFOLIO SCREENING METHODOLOGY

Once the Once potential sources were organized into portfolios, each portfolio was further screened using a series of weighted criteria to determine the best possible option to meet NUA's needs. Weighted criteria were used so that a low capital cost was not the only driver for portfolio selection The weighted criteria were developed using a paired comparison analysis that included members of the Strategic Water Supply Plan Ad Hoc Committee, NUA staff, trustees, and chairman. The criteria used in the Water Supply Plan and their respective weights are presented in Figure 11-3.

Figure 11-3: 2060 Water Supply Plan Weighted Screening Criteria



11.1.4 2060 WATER SUPPLY PLAN COST SUMMARY

The capital cost for each portfolio in the 2060 Water Supply Plan were escalated to 2023 dollars using the Construction Cost Index value of 1.4. This value was derived from the ratio of construction costs between 2012 and 2023 in Dallas, Texas. The capital costs for each portfolio are presented in Figure 11-4. The unit costs for each alternative were also escalated to 2023 dollars and are shown in Figure 11-5.

Figure 11-4: Escalated Capital Cost for Each Portfolio

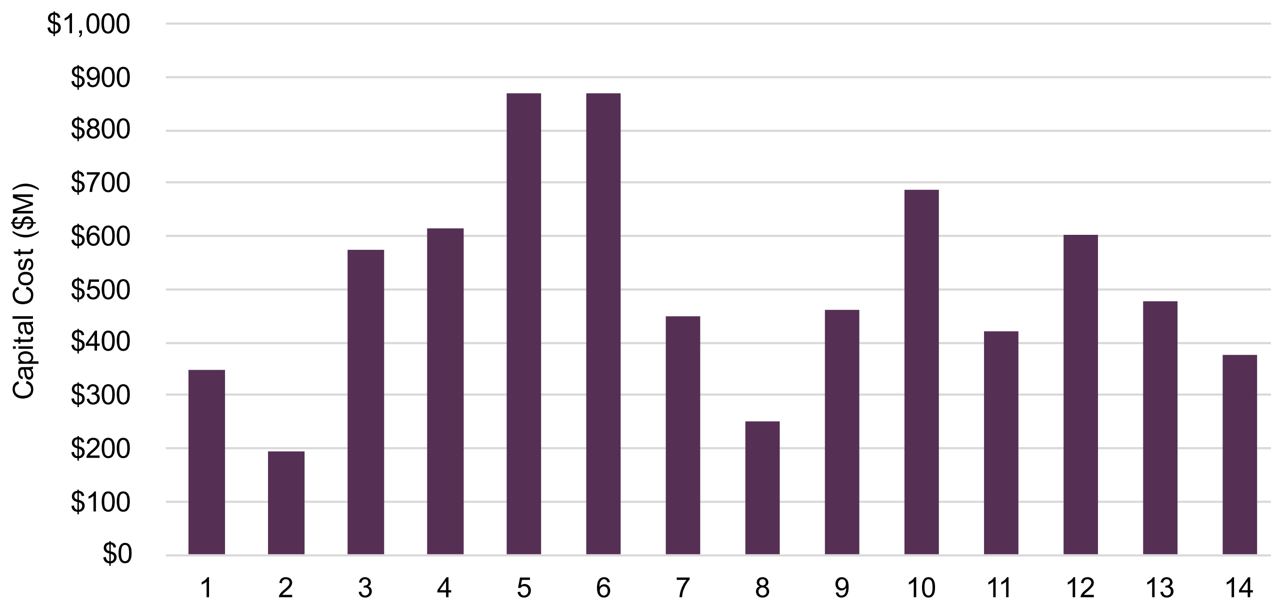
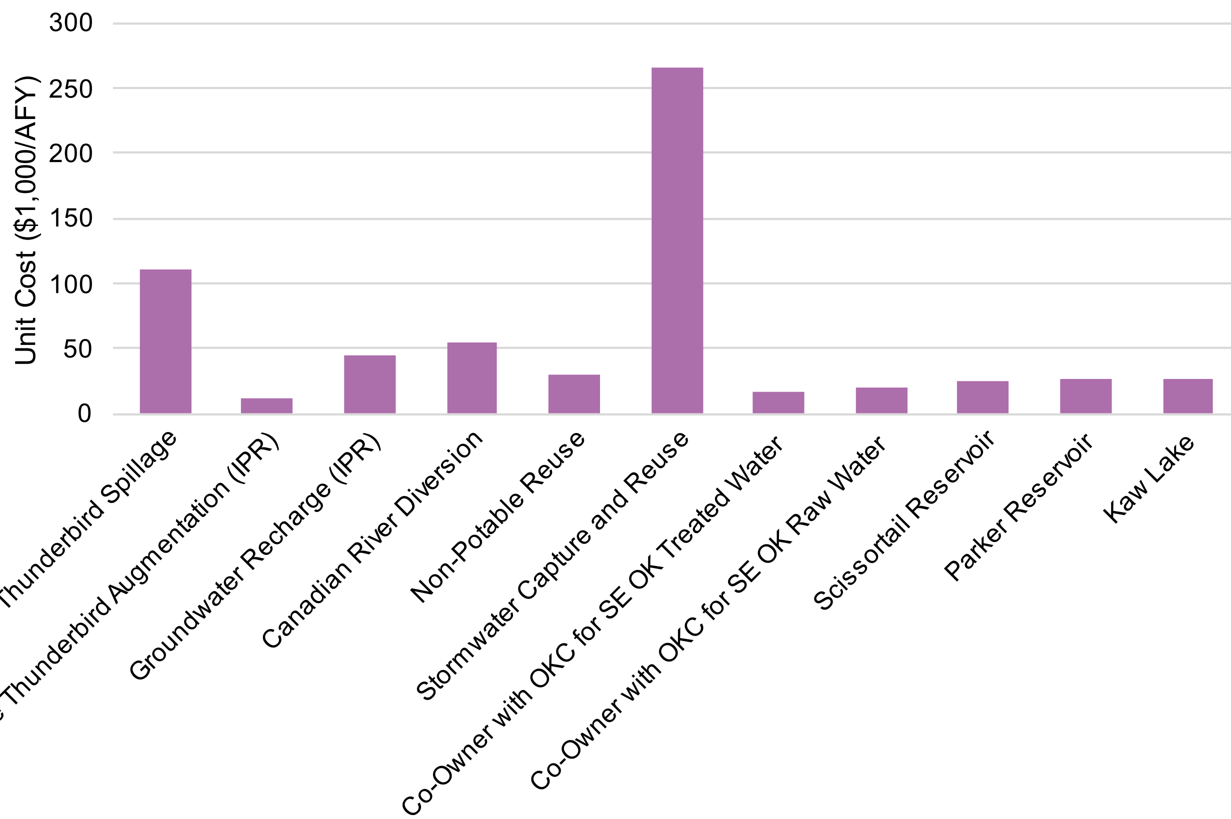


Figure 11-5: Escalated Unit Cost for Each Water Supply Alternative



11.1.5 2060 WATER SUPPLY PLAN SHORT-LISTED PORTFOLIO

Following the screening process discussed, the 2060 Water Supply Plan identified Portfolios 1, 13, and 14 for more in-depth review and consideration. All three of these short-listed portfolios used similar sources and all include the three existing sources used by NUA. The sources included in the three short-listed portfolios are listed below:

- Additional Conservation
- Garber-Wellington Groundwater Wells
- IPR via Lake Thunderbird Augmentation
- Non-Potable Reuse
- Purchase Water from OKC
- Surface Water from Lake Thunderbird

It was previously determined in the 2060 Water Supply Plan that Portfolio 14 would best meet NUA's needs. This portfolio would use the continued use of surface water from Lake Thunderbird and Garber-Wellington groundwater wells and included the implementation of additional conservation. This report also identified both non-potable reuse, and IPR as the best new sources. New sources would be used to meet the projected supply gaps. Figure 11-6 shows the difference between the existing volume from each supply and the anticipated volume to meet projected average and maximum daily demands.

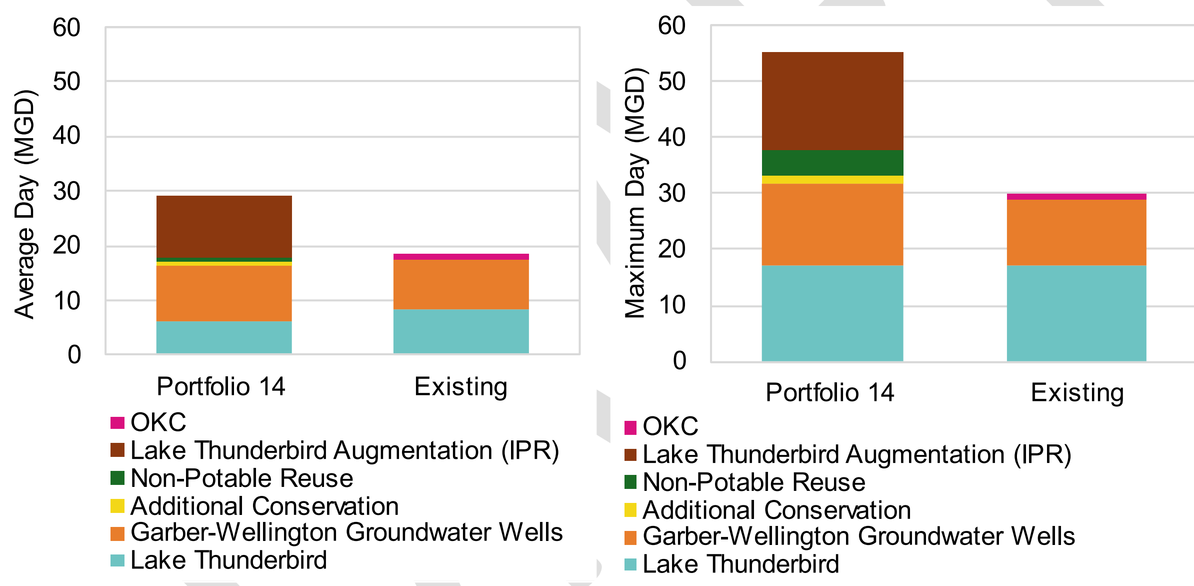


Figure 11-6 : Portfolio 14 Sources vs. Existing Sources

11.2 SOURCE ALTERNATIVES

Garver re-evaluated the potential water supply sources outlined in the 2060 Water Supply Plan. Since the 2014 publication date, multiple water supply sources that were presented in the report have since been deemed non-viable for various reasons. In contrast, new source alternatives have since become available, and additional source alternatives were added. The potential supplies presented in the 2060 Water Supply Plan currently under consideration are the following:

- Garber-Wellington Groundwater Wells
- Lake Thunderbird
- Lake Thunderbird Augmentation (IPR)
- New In-Basin Reservoir
- New Out-of-Basin Reservoir (Parker or Scissortail)
- Purchased Finished Water from OKC

The new potential water supply alternatives include the following:

- Alluvial Wells
- Direct Potable Reuse (DPR)

11.2.1 LAKE THUNDERBIRD

Lake Thunderbird is an existing reservoir located within the city limits. The reservoir was created following the construction of the Norman Dam on the Little River in 1965. The reservoir was created with the intended purpose of providing municipal water supply to nearby utilities. Lake Thunderbird is currently managed by the Central Oklahoma Master Conservancy District (COMCD) and the reservoir's yield is currently shared between the City, Del City, and Midwest City in proportion to the costs that were incurred by each municipality when constructing the dam, reservoir, pumping station, and other associated infrastructure. NUA is currently allocated 43.8% of the permitted yield for Lake Thunderbird, while Midwest City and Del City receive 40.4% and 15.8%, respectively.

Water from Lake Thunderbird is pumped to the existing Vernon Campbell WTP via 8.5 miles of 30-inch concrete and 48-inch fiberglass raw water transmission lines. The Vernon Campbell WTP uses conventional treatment and softening and has a peak treatment capacity of 17.0 MGD.

11.2.1.1 CURRENT USAGE

Water from Lake Thunderbird is currently the largest source of supply within NUA and makes up 70% of the water used to meet system demands. Water rights to Lake Thunderbird are permitted based on the reservoir's total annual yield of 7,038 MG (19.3 MGD). NUA's allocation is 3,084 MG annually (8.5 MGD) under normal conditions.

There have been multiple studies and reports conducted by the BOR since construction of the reservoir. Lake Thunderbird's total permit availability was established and has been maintained at 21,600 AFY, or 19.3 MGD. However, this permitted yield, or conjunctive yield, has differed from subsequent firm yield modeling efforts conducted by the BOR. The latest firm yield modeling effort by the BOR was presented to the COMCD in September 2021 and produced a firm yield of 12,700 AFY, or 11.3 MGD, for Lake Thunderbird.

This modeling effort did not consider any mitigation measures such as demand management, curtailment, or augmentation. As such, there are risks associated with the long-term firm yield of Lake Thunderbird during significant drought events. However, the BOR has maintained that the lake will continue to be managed around the permitted yield of 21,600 AFY.

11.2.1.2 CONTINUED USAGE

NUA has exceeded their allocation in recent years due to the reservoir being above its flood pool elevation. When the water level at Lake Thunderbird exceeds 1,039.0 feet, NUA can utilize temporary water rights to consume water in the flood pool that is not counted towards their annual allocation. The consumption of water from Lake Thunderbird over the last four years is shown in Figure 3-2.

The usage of flood pool water coupled with potential decrease in permitted surface water rights to Lake Thunderbird discussed in Section 10.1 have the potential to impact NUA's water supply options, especially in dry years when access to flood pool water will not be available. The future availability and usage of Lake Thunderbird will ultimately be dependent on the future permitted water rights and weather patterns.

11.2.2 GARBER-WELLINGTON GROUNDWATER WELLS

The Garber-Wellington Aquifer underlies 2,891 square miles under portions of Cleveland, Logan, Lincoln, Oklahoma, Payne, and Pottawatomie counties in central Oklahoma. Currently, NUA holds temporary permits to the groundwater rights from the Garber-Wellington Aquifer, which has an equal proportionate share of 2.0 acre feet (AF)/acre/year. Previous studies completed by Oklahoma Water Resource Board (OWRB) and the Association of Central Oklahoma Governments have determined that the recharge rate is less than 2 AF/acre/year, but that overall usage is such that there is not a need to decrease the equal proportionate share value.

11.2.2.1 CURRENT USAGE

NUA currently owns 66 groundwater wells within the Garber-Wellington Aquifer with only 43 being active and the remaining 23 wells being inactive. Inactive wells were taken offline due to the level of arsenic exceeding the regulatory MCL value of 10 parts per billion (ppb) or due to age and physical failures. Historical flow data suggests that these inactive groundwater wells have a combined average yield of approximately 2.1 MGD and 2.7 MGD under peak conditions.

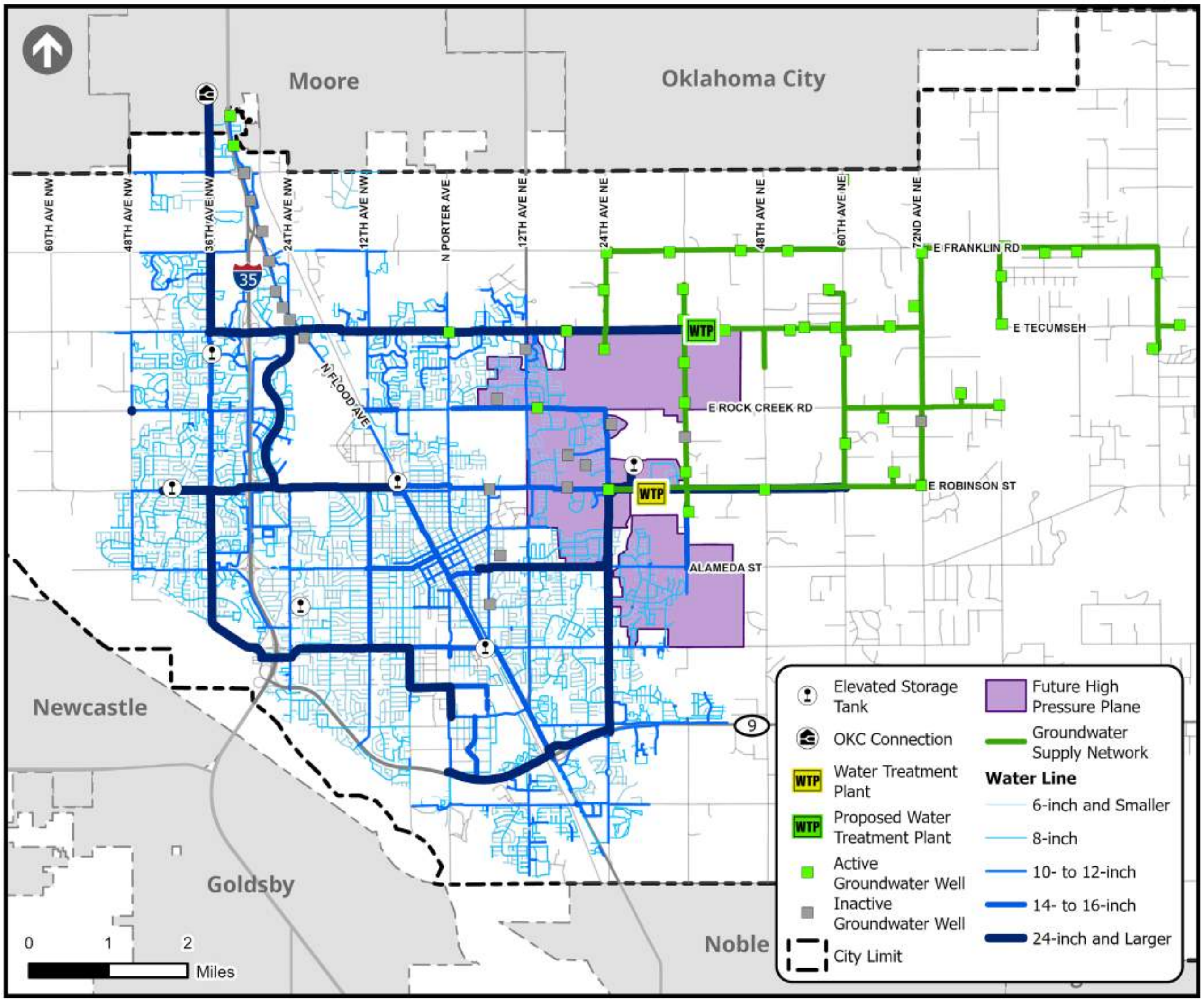
The active groundwater wells have an average yield of 6.5 MGD, and 12.0 MGD can be achieved under peak operating conditions. However, this volume cannot be continuously maintained as reduced well production has been noted following periods of peak operation. All active wells currently meet existing water quality standards, and no additional treatment is necessary. Currently, the water from these groundwater wells is pumped directly into the distribution system without receiving treatment.

11.2.2.2 CONTINUED USAGE

As water quality concerns rise and regulatory standards become more strict, there is concern that water from the groundwater wells will not be able to be pumped directly into the distribution system. It is anticipated that a new groundwater WTP will need to be constructed near Tecumseh Road and 36th Avenue Northeast to treat groundwater from these wells. It is also anticipated that all existing groundwater transmission water lines will be converted into a future groundwater supply network, as shown in Map 11-1. This groundwater supply network will convey flow from the existing groundwater wells to a proposed groundwater WTP which is currently under design.

The addition of the new groundwater WTP would also allow some inactive groundwater wells to be reactivated and used as supply. However, additional water lines would need to be constructed to convey water from each of the inactive groundwater wells to this facility since the water quality does not meet the current regulatory requirements. Most inactive wells are located within the northern portion of the WSA along Flood Avenue and in the central portions of the WSA west of the Vernon Campbell WTP.

Map 11-1: Proposed Groundwater WTP Location



11.2.3 PURCHASED WATER FROM OKC

Since 2000, NUA has had the ability to purchase treated water from OKC via a connection in the northernmost part of the WSA. In 2015, NUA entered into an agreement with OCWUT to regularly purchase treated water based on a subscribed monthly capacity reservation of approximately 1 MGD.

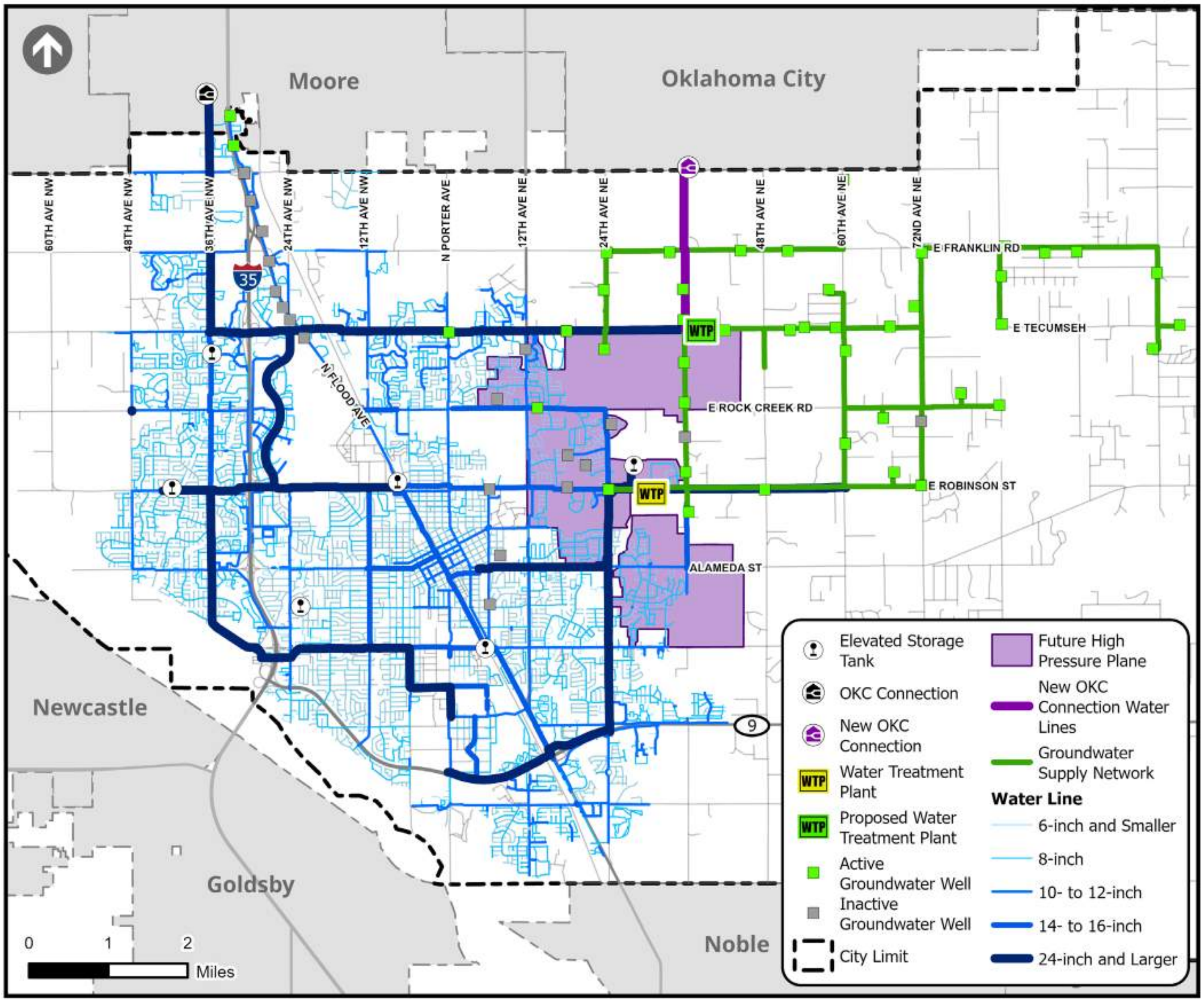
11.2.3.1 CURRENT USAGE

NUA currently receives treated water from OKC via one connection point located at the northwestern boundary of city limits. There is the option to receive more water than the subscribed 1 MGD to meet demands during peak periods. Maximum potential delivery is about 6.0 MGD depending on the pressure differential between the two systems.

11.2.3.2 CONTINUED USAGE

It is recommended that an additional connection point be constructed if purchased water from OKC exceeds 6 MGD. Based on future land use and anticipated growth, it is recommended that the second OKC connection be constructed in the northeastern portion of the WSA. However, further analysis and discussion with OKC would be necessary to determine the ideal position. The proposed location would allow for better distribution of water to areas where future growth is anticipated. Map 11-2 shows the recommended location of this additional connection point.

Map 11-2: Recommended Future OKC Connection



11.2.4 REUSE

The City and NUA are dedicated to advancing sustainable water management practices to support the long-term viability of its water resources. This section outlines the following strategies for the effective reuse of treated wastewater to support the community's water needs.

- Review Indirect Potable Reuse (IPR) Alternatives and Implementation: Explore the process, benefits, costs, and drawbacks of implementing IPR.
- Explore the Options of Direct Potable Reuse (DPR): Explore the process, benefits, costs, and drawbacks of implementing DPR.

For many years, NUA has evaluated the use of reclaimed water as a potential source. Additionally, they prompted the state to begin formulating regulatory criteria for IPR and carried out a comprehensive pilot study to demonstrate treatment efficacy and water quality.

At present, there are no regulations for DPR in Oklahoma. Establishing regulatory framework for DPR projects would likely be necessary before implementation, which could involve several years of pilot testing and regulatory discussions. The DPR design proposed here draws on experiences from previous projects in other states and follows a conservative approach, incorporating high-pressure reverse osmosis membranes as a physical barrier against pathogens, along with advanced oxidation processes to manage contaminants of emerging concern.

11.2.4.1 LAKE THUNDERBIRD AUGMENTATION (IPR)

IPR would allow NUA to augment the Lake Thunderbird water supply with treated water from their existing water reclamation facility (WRF). To utilize the existing WRF for IPR the following improvements would be necessary:

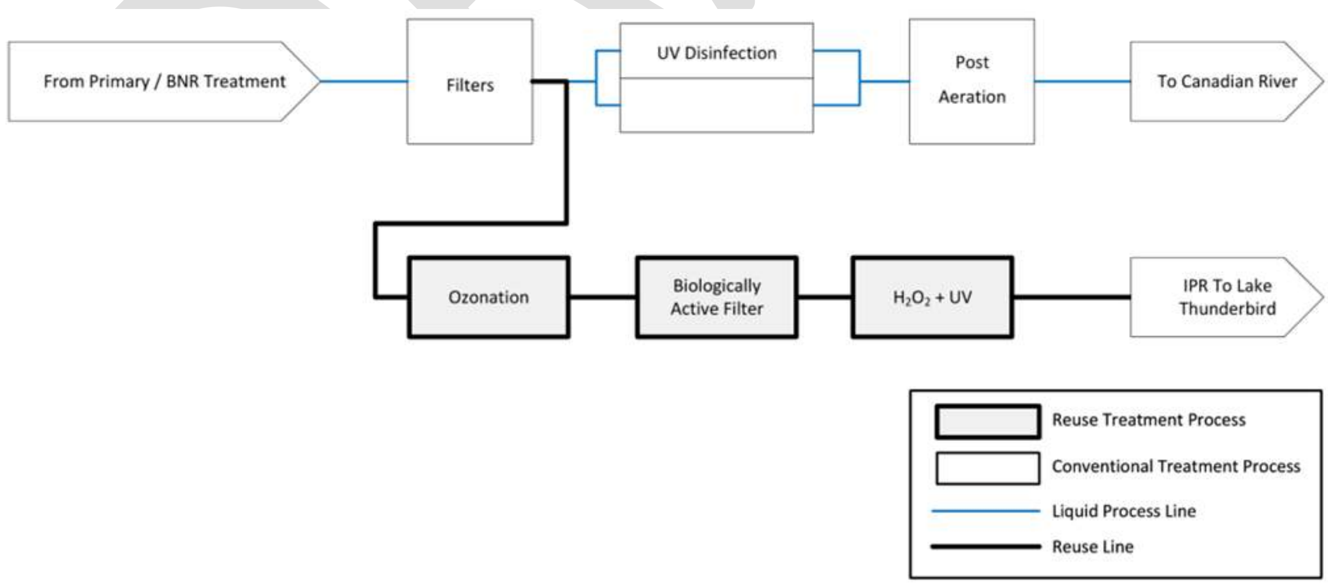
- Increase the existing WRF capacity by 10 MGD for a total of 26 MGD
- Upgrade the existing WTP capacity by 15 MGD for a total of 31 MGD
- Additional conveyance from Lake Thunderbird to the existing WTP
- Construct effluent pipeline from the existing WRF into the nearest Dave Blue Creek tributary

This reuse option would require the production of high-quality wastewater that has been treated to a standard suitable for discharge to a drinking water supply source. Effluent would be redirected from the flow discharged to the Canadian River where it will receive additional treatment including: ozonation, biologically active filtration (BAF), and high-intensity UV disinfection with hydrogen peroxide, functioning as an advanced oxidation process (AOP).

Ozonation provides strong oxidation to further disinfect and break down organic chemicals in the effluent, some of which are metabolized and further broken down by bacteria in the BAF. Ozone improves clarity, taste, and odor. The UV/AOP process provides a final step to both disinfect as well as further oxidize chemical compounds, such as contaminants of emerging concern.

Finally, effluent is discharged to Lake Thunderbird where is can be pumped from Lake Thunderbird to the Vernon Campbell WTP. Once at the WTP, water will undergo treatment to achieve potable standards before entering the distribution system. Figure 11-7 shows the proposed treatment process for IPR.

Figure 11-7: Proposed Process Flow Diagram for IPR



A more detailed review of IPR implementation can be found in the Reuse Evaluation Technical Memorandum included as Appendix E.

11.2.4.2 DIRECT POTABLE REUSE

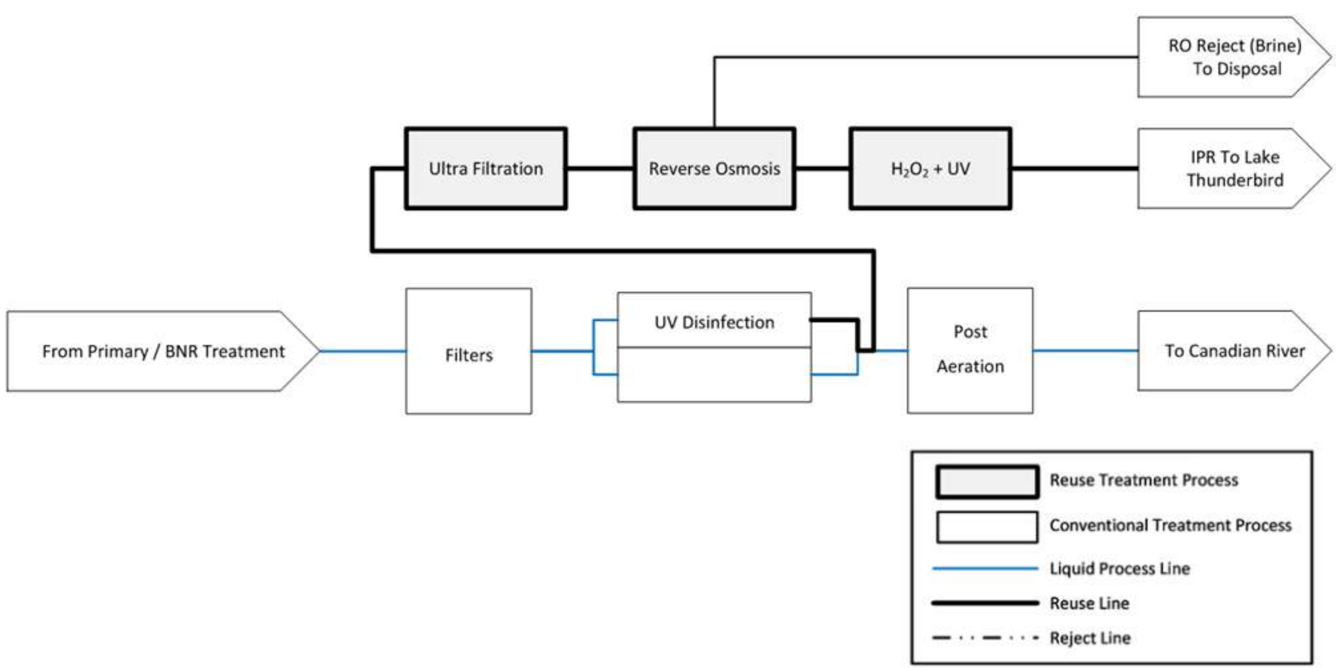
DPR involves the routing of highly treated wastewater effluent to a drinking water facility without first passing through an environmental buffer. To implementation of DPR the following improvements would be necessary:

- Increase the existing WRF capacity by 10 MGD for a total of 26 MGD
- Upgrade the existing WTP capacity by 15 MGD for a total of 31 MGD
- Construct a new DPR effluent pipeline from the existing WRF to the WTP
- Additional conveyance from Lake Thunderbird to the existing WTP
- 5 MGD of storage capacity near the WTP to smooth effluent pumping between changes in WRF output and WTP demand

DPR includes extra treatment like UF and RO membranes to address the lack of natural dilution, which increases costs beyond that of IPR. Despite the higher expenses, DPR offers NUA the advantage of providing water supply without needing approval from Lake Thunderbird stakeholders. Challenges include managing RO brine disposal and the absence of existing DPR regulations in Oklahoma, which could require lengthy piloting and approval processes.

DPR for NUA is recommended to include three main elements: UF membranes, RO membranes, and high-energy UV/AOP. UF membranes remove fine suspended solids, and RO membranes remove most dissolved or suspended compounds and all larger compounds, viruses, and bacteria. Due to the fine membrane size of both UF and RO a pressure above 100 psi is required, none of which is recovered. Hence RO consumes a significant amount of electricity compared to other processes. RO filtrate passes through the membranes, but a minority of the flow concentrates the impurities and is discharged as concentrate, also known as reject or brine. Figure 11-8 shows the proposed treatment process for DPR.

Figure 11-8: Proposed IPR Process Flow Diagram



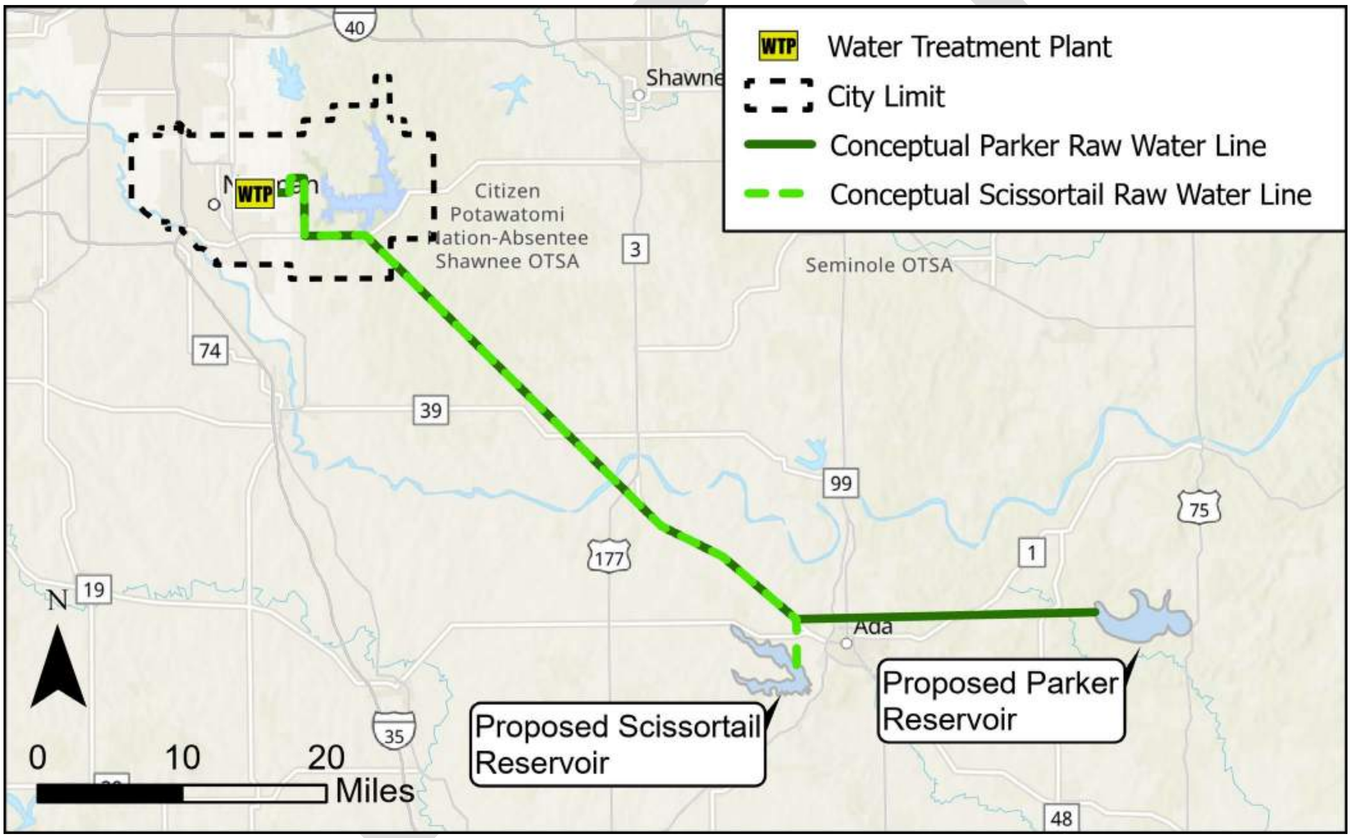
Three potential inland brine disposal options include: dilution into non-reuse effluent, drying beds, deep well injection. Brine may be diluted back into the original effluent stream into the Canadian River which would introduce a concentrated stream of undesirable chemicals and salts to the river. It is unknown if permitting would be approved for this brine disposal option. If dilution into the Canadian River is not permitted, drying beds could be used as a brine disposal option. However, the anticipated 2 MGD of reject stream will require a large amount of land area to be dedicated to drying. Drying beds were deemed not feasible due to existing climate and the large land area that would be required. Lastly, deep well injection could be implemented if the geology proves favorable. Impurities and salts would be injected with the brine stream into a permeable geological layer determined to be hydraulically isolated from usable groundwater above. Geologically suitable locations are not guaranteed to be found nearby, and may require extensive exploration, pipelines, and potentially injections pumps. This brine disposal option was assumed for the purposes of this evaluation.

A more detailed review of DPR implementation can be found in the Reuse Evaluation Technical Memorandum included as Appendix E.

11.2.5 NEW OUT-OF-BASIN RESERVOIR

Two potential out-of-basin reservoirs located southeast of the NUA WSA have been discussed as potential sources. Both the Scissortail and Parker Reservoirs have been previously reviewed to determine feasibility and potential yields. The proposed locations of the reservoirs are shown in Map 11-3.

Map 11-3: Proposed New Out-of-Basin Reservoirs



11.2.5.1 SCISSORTAIL RESERVOIR

The proposed location of the Scissortail Reservoir is about 60 miles southeast of the NUA WSA near the City of Ada. The most recent study related to the Scissortail Reservoir was completed in 2009 by the City of Ada. During this evaluation it was determined that the anticipated storage volume of the reservoir would be about 117,524 AF, with a firm yield of 32,000 AFY (28.6 MGD). At the time the evaluation was completed, Ada's anticipated average demand was 8.7 MGD, potentially leaving 19.9 MGD average yield for NUA.

11.2.5.2 PARKER RESERVOIR

The proposed location of the Parker Reservoir is about 75 miles southeast of the NUA WSA and 15 miles east of the City of Ada. The most recent study related to the Parker Reservoir was completed in 2010 by OWRB. During this evaluation it was determined that the anticipated storage volume of the reservoir would be about 220,240 AF, with a firm yield of 45,900 AFY (40.0 MGD).

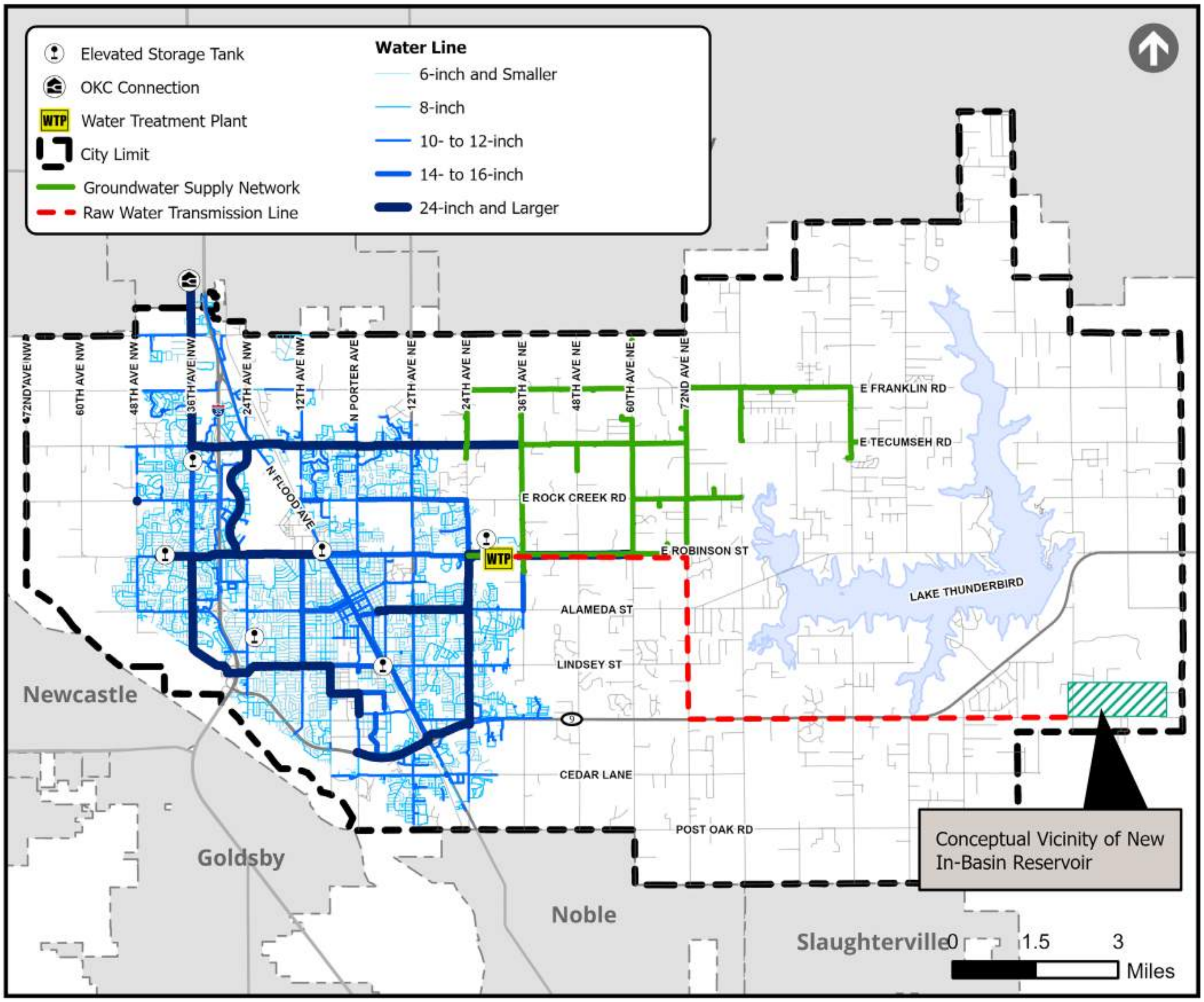
The Parker Reservoir would be developed for use solely by NUA, and not in conjunction with any other utilities. Therefore, NUA would incur all the capital costs related to the development of the reservoir. However, other nearby utilities have expressed interest in involvement of the reservoir, which would allow NUA to sell or collaborate with other potential users to reduce the capital cost of this source option.

11.2.6 NEW IN-BASIN RESERVOIR

While the primary use of Lake Thunderbird is municipal supply, the reservoir is also used for flood mitigation purposes. Flood pool volumes are managed via releases from Lake Thunderbird with consideration to future weather predictions, inflows to Lake Thunderbird, and downstream conditions.

A new reservoir could be constructed that would allow for diversion of released water, and the proposed location of this reservoir is shown in Map 11-4. This new reservoir would act as a terminal storage reservoir for NUA with an anticipated firm yield of approximately 5.8 MGD. However, the diversion of surface water is permitted by OWRB, and the diversion of released water into the in-basin reservoir may impact users downstream, which could impact the permitted yield available to NUA. This alternative would also require the construction of an additional 15 miles of raw water transmission lines to convey water from the new reservoir to the existing WTP.

Map 11-4: Proposed New In-Basin Reservoir

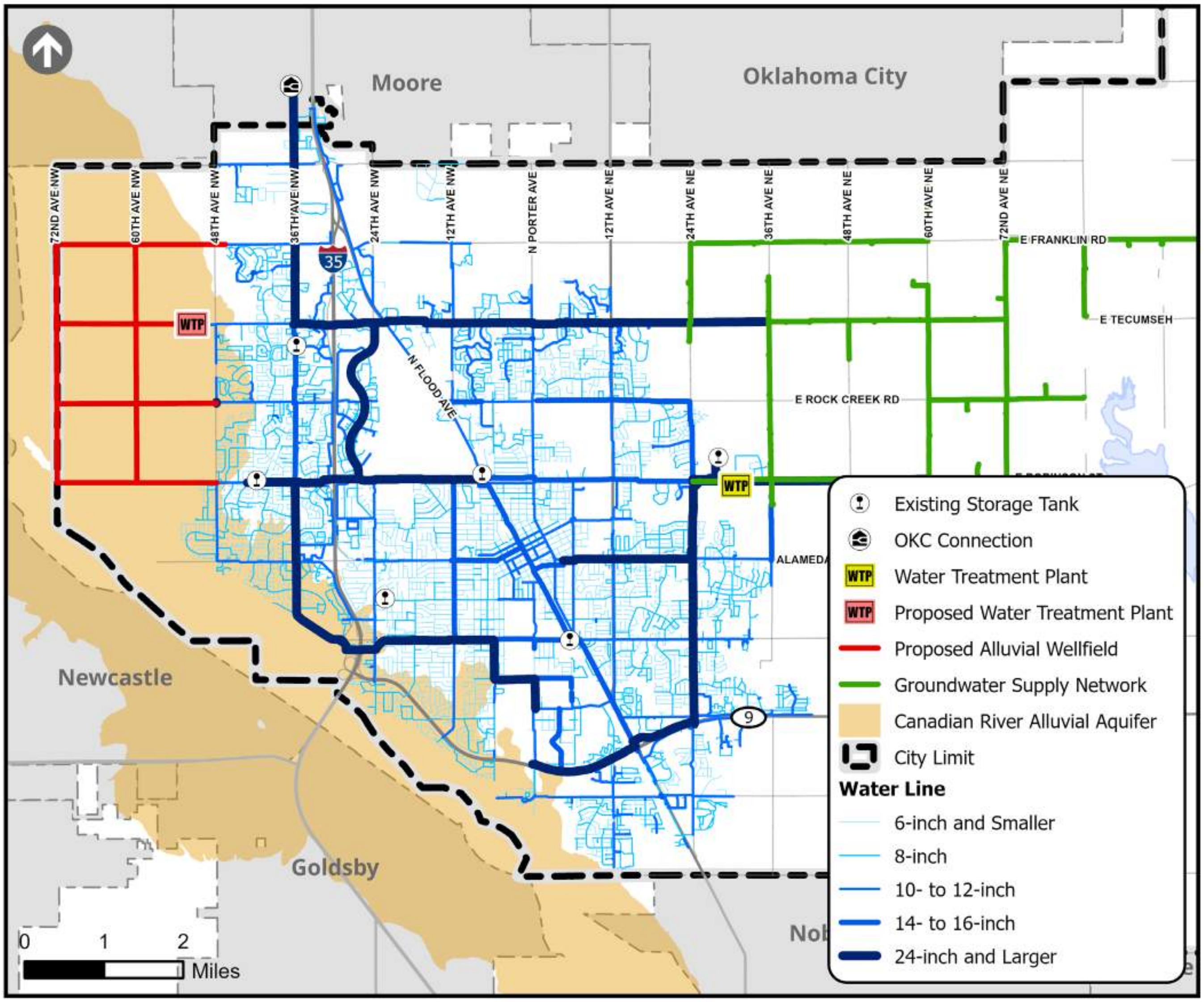


11.2.7 ALLUVIAL WELLS

The Canadian River Alluvial Aquifer underlies approximately 17 square miles (10,880 acres) in the western portion of the system near the municipal boundary, as shown in Map 11-5. Based on previous well records from OWRB, it is anticipated that wells will average around 400 feet deep, but actual depth will be determined with test well drilling. It is also anticipated that the wells will have an average yield of 300 gpm when viable geology is located and drilled. However, alluvial aquifers can be very susceptible to droughts which could also lead to variable yields from the wellfield based on weather patterns.

To produce enough water to meet the desired 10 MGD capacity, NUA would have to construct a well field with approximately 46 wells, 15.4 miles of raw transmission lines, and a new centralized WTP near the wellfield. Further investigation will be necessary to determine feasibility of an alluvial well field in this location. This investigation would be needed to confirm well yields which could affect the number of wells needed or the land required for water rights to meet the desired 10 MGD capacity. These investigations will also be necessary to identify any issues with water quality and the treatability of the water from these wells. Both the yield and the water quality can greatly impact the cost and overall feasibility of this alternative.

Map 11-5: Canadian River Alluvial Aquifer



12.0 WATER SUPPLY ALTERNATIVES COST ANALYSIS AND PRIORITIZATION

12.1 NON-MONETARY CRITERIA

Along with the re-evaluation of the potential sources, Garver also updated the criteria used for source selection. The updated non-monetary criteria can be found in Table 12-1. Each criterion was weighted on a scale of 1 to 5, with 1 being the lowest weight and 5 being the highest weight. The use of non-monetary criteria allows the City's priorities to be properly reflected during the selection process and shows that project cost is not the sole driver when selecting alternatives.

Table 12-1: Updated Non-Monetary Criteria

Criterion	Summary	Average Criteria Weight[1]
Environmental Impacts	Supply should minimize negative environmental impacts	4.4
Flexibility	Supply should be able to be phased into the system and accommodate changes to demand and regulations	4.1
Expandability	Supply should include the ability for extension of water supply to meet demands beyond 20 years	4.0
Implementability	Supply can be implemented with regulatory approvals before additional supply is needed	4.5
Independence	Supply will result in NUA holding the water rights and owing/operating the system as opposed to purchasing water	3.1
Public Acceptance	Supply should be acceptable to system customers	3.6
Reliability	Water resources yield should be secure for planning horizon and not subject to reduction or loss	4.6
Redundancy	Water supply minimizes single points of failure and provides elements of redundancy within the system	4.1
Drought Resistance	Supply should be resilient to severe or long-term drought	4.4

Notes:

1. Rated on a scale of 1 to 5, with 5 being most important by AIM Norman Water and Wastewater Sub-Committee, NUA staff, and Garver. The average of all scores was used as the weighted average for non-monetary scoring purposes.

A non-monetary scoring exercise was completed and discussed across multiple meetings, including the August Sub-Committee meeting on August 30, 2024, by the AIM Norman Water and Wastewater Sub-Committee, NUA staff, and Garver. The individual scores for each source from the AIM Norman Water and Wastewater Sub-Committee are presented in Table 12-2. The total score for each source from each scoring group is presented in Table 12-3.

The overall rankings for each scoring group are presented in Table 12-4. A weighted composite score was also calculated. This weighted score was calculated using a 50% weight for AIM Norman Water and Wastewater Sub-Committee and 25% weight for both NUA staff and Garver to determine the composite score. Across all three scoring groups, the new groundwater wells scored the best, while alluvial wells and a new out-of-basin reservoir scored the lowest.

Table 12-2: AIM Norman Water and Wastewater Sub-Committee Non-Monetary Scoring by Source

Criterion	Weight	Garber-Wellington Groundwater Wells Score	Lake Thunderbird Augmentation (IPR) Score	OKC Water Supply Score	New Out-of-Basin Reservoir (Parker or Scissortail) Score	Direct Potable Reuse Score	Alluvial Wells (Canadian River) Score
Environmental Impacts	4.4	4.1	4.3	3.9	3.1	4.8	3.9
Flexibility	4.1	4.4	4.0	4.5	3.1	3.9	3.8
Expandability	4.0	4.3	3.8	3.4	3.6	3.9	3.5
Implementability	4.5	4.4	3.3	4.8	2.6	3.0	3.5
Independence	3.1	4.6	4.1	2.1	3.5	4.1	3.8
Public Acceptance	3.6	3.9	3.3	3.6	3.3	3.0	4.0
Reliability	4.6	4.4	3.9	4.1	3.8	3.6	3.5
Redundancy	4.1	4.4	3.8	3.9	3.8	3.6	3.9
Drought Resistance	4.4	4.3	4.5	3.6	3.4	4.4	2.9
Average	-	4.3	3.9	3.8	3.3	3.8	3.7
Total	36.9	158.3	142.5	141.2	123.5	140.5	134.7

Notes:

1. Each alternative is ranked on a scale of 1-5, with 5 being the most favorable alternative

Table 12-3: Non-Monetary Total Score by Scoring Group

Scoring Group	Garber-Wellington Groundwater Wells	Lake Thunderbird Augmentation (IPR)	OKC Water Supply	New Out-of-Basin Reservoir (Parker or Scissortail)	Direct Potable Reuse	Alluvial Wells (Canadian River)
AIM Norman Sub-Committee	158.3	142.5	141.2	123.5	140.5	134.7
City Staff	158.2	141.6	148.3	120.3	139.4	130.6
Garver	132.9	129.5	125.3	92.9	115.7	107.0
Composite[1]	151.9	139.0	139.0	115.1	134.0	126.8

Notes:

1. Composite score for each alternative were calculated by taking the sum of each group's non-monetary score and their respective scoring weight:
    - AIM Norman Sub-Committee – 0.50
    - City Staff – 0.25
    - Garver – 0.25

Table 12-4: Non-Monetary Score Rankings

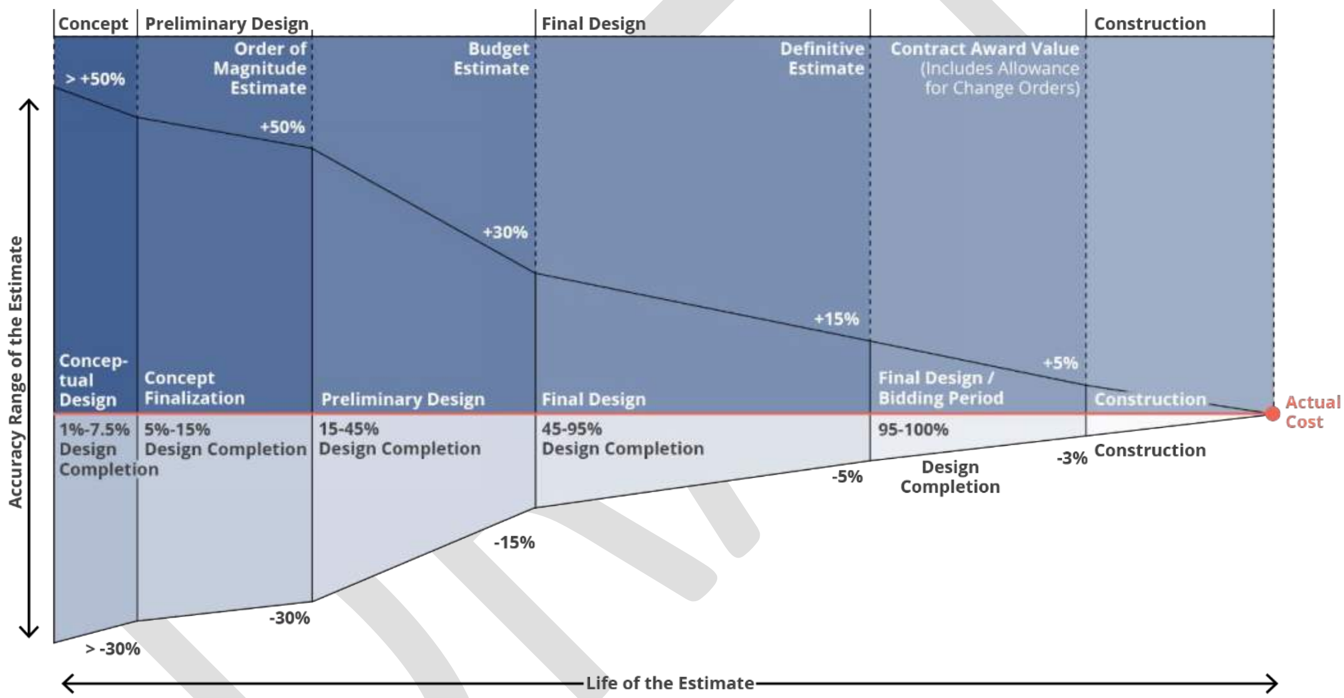
Scoring Group	Ranking					
	First	Second	Third	Fourth	Fifth	Sixth
AIM Norman Sub-Committee	Groundwater Wells	IPR	OKC	DPR	Alluvial Wells	New Reservoir
City Staff	Groundwater Wells	OKC	IPR	DPR	Alluvial Wells	New Reservoir
Garver	Groundwater Wells	IPR	OKC	DPR	Alluvial Wells	New Reservoir

12.2 SUPPLY ALTERNATIVE COST ANALYSIS

The cost estimates included in this costs analysis are Class 4 estimates as defined by the Association for the Advancement of Cost Engineering (AACE), which is consistent with cost estimates developed for studies. The expected accuracy range for the estimates is -30% to +50% of the estimated values. Additional details will need to be developed for each project to develop Class 3 estimates for budget authorization or control. Based on the current market volatility in 2024, factors such as material and labor shortages may impact project costs. Labor shortages typically reduce the number of bidders for infrastructure projects, and the bids received are generally higher to account for the uncertainty in labor costs. Material selection based on current conditions and direct procurement may be beneficial to control costs and reduce uncertainty in project schedules.

Generally based on guidance from AACE, Figure 12-1 shows that each project phase milestone will result in further delineation of the project elements, resulting in tighter ranges of accuracy as the project progresses. Figure 12-1 is an example of how the project estimate's accuracy uncertainty will decrease as the project develops.

Figure 12-1: Project Cost Funnel



Garver updated the total capital costs from those presented in the 2060 Water Supply Plan for each water supply options being considered. Portions of these costs were escalated to 2023 dollars using the Construction Cost Index value of 1.4. This value was derived from the ratio of construction costs between 2012 and 2023 in Dallas, Texas. Other portions were developed by Garver based on industry standards. These water supply alternatives, their respective capacities, and the estimated total project costs are shown in Table 12-5,vv and In-depth cost tables can be found Appendix F.

Table 12-5: Water Supply Alternatives Costs

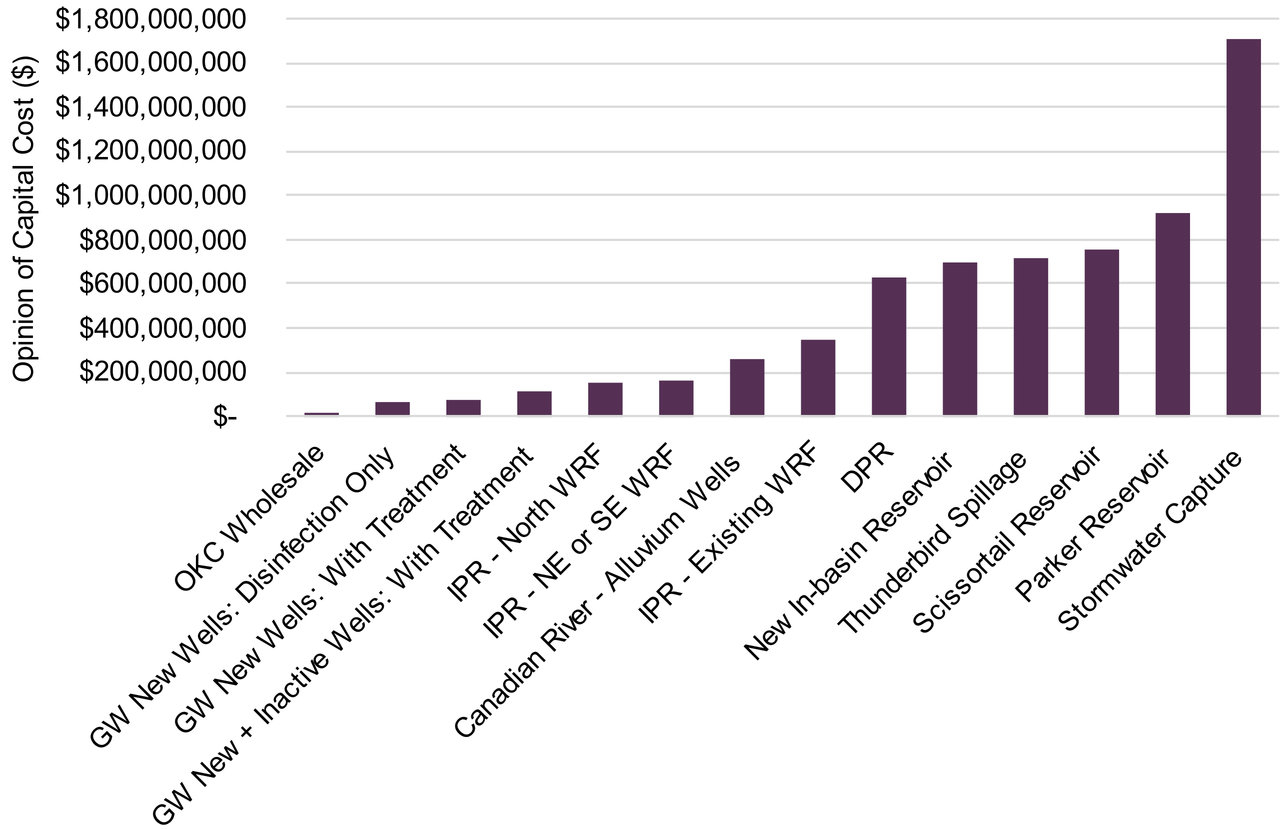
Water Supply Alternative	Anticipated Capacity (MGD)	Total Project Cost
Stormwater Capture	5.8	$1,708,000,000
Parker Reservoir	29.1[1]	$922,895,000
Scissortail Reservoir	19.9	$756,522,000
Thunderbird Spillage	5.8	$714,000,000
New In-Basin Reservoir	5.8	$694,941,000
DPR	10.0	$631,922,000
IPR – Existing WRF	10.0	$350,828,000
IPR – North WRF	5.0	$153,731,000
IPR – NE or SE WRF	5.0	$163,265,000
Alluvium Well	10.0	$255,667,000
GW New Wells: Disinfection Only	5.0	$67,848,000
Groundwater New Wells and Inactive Wells: With Treatment	5.3	$114,281,000
Groundwater New Wells: With Treatment	5.0	$76,308,000
OKC	6.0	$19,130,000

Note:

1. The Parker Reservoir would have a firm capacity of 40 MGD but it is anticipated that through the 2045 planning horizon that only 29.1 MGD would be needed.

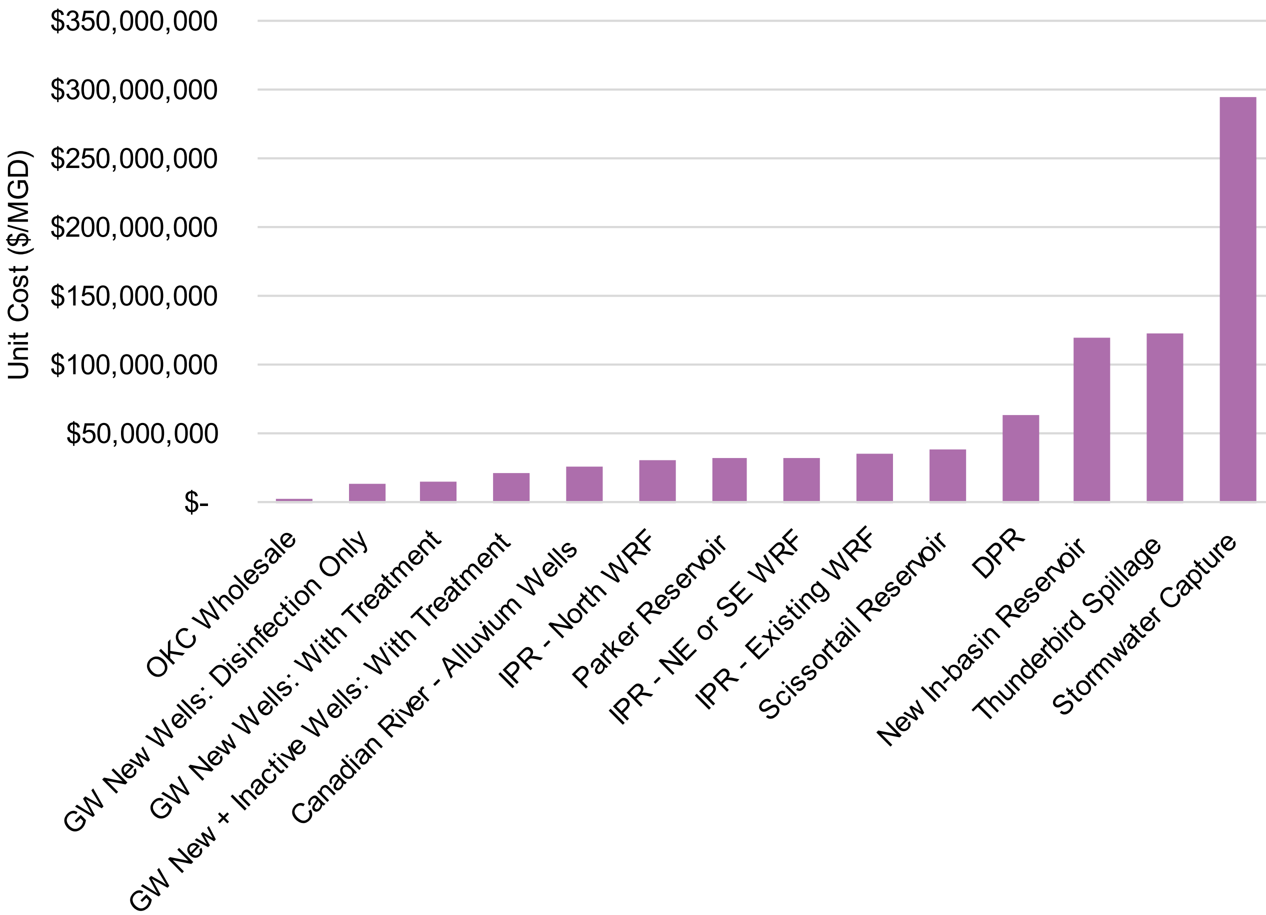
The opinion of probable construction costs (OPCC) presented represents the capital costs needed to design, permit, build, and construct new infrastructure, which includes professional services, contingencies, and land acquisition. The OPCC for all current water supply options being considered are presented in Figure 12-2.

Figure 12-2: Water Supply Alternatives Opinion of Capital Costs



Garver also developed the unit capital costs for each water supply alternative based on the OPCC and the anticipated capacity of each source. These unit costs are presented in Figure 12-3. Following the development of each alternative's unit cost, the alternatives with a unit cost of less than $60M/MGD were considered for further evaluation.

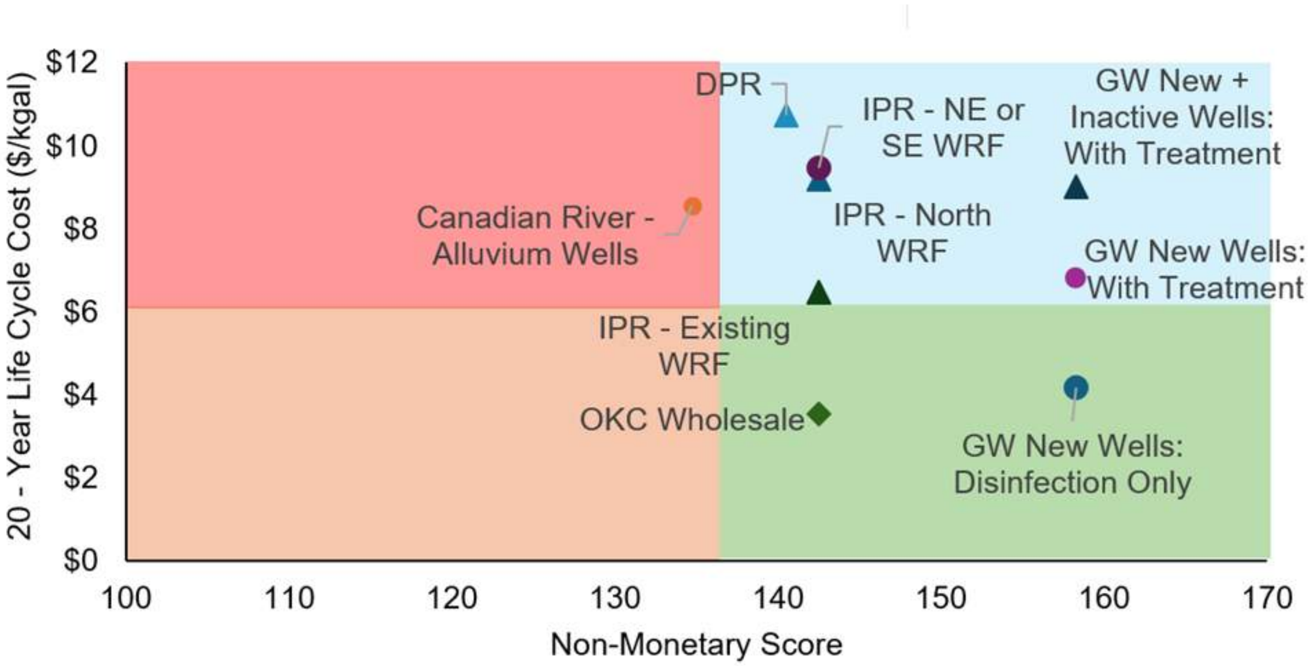
Figure 12-3: Water Supply Alternatives Unit Costs



12.3 COMBINED MONETARY AND NON-MONETARY EVALUATIONS

To compare all alternatives, the monetary and non-monetary scores were plotted on a heat map for comparison. A heat map showing 20-year life cycle costs is presented in Figure 12-4. The ideal alternatives are in the green portion of the heat map, which correlates to a high non-monetary score and a comparatively low life-cycle cost.

Figure 12-4: Non-Monetary Score vs. 20-Year Life Cycle Cost



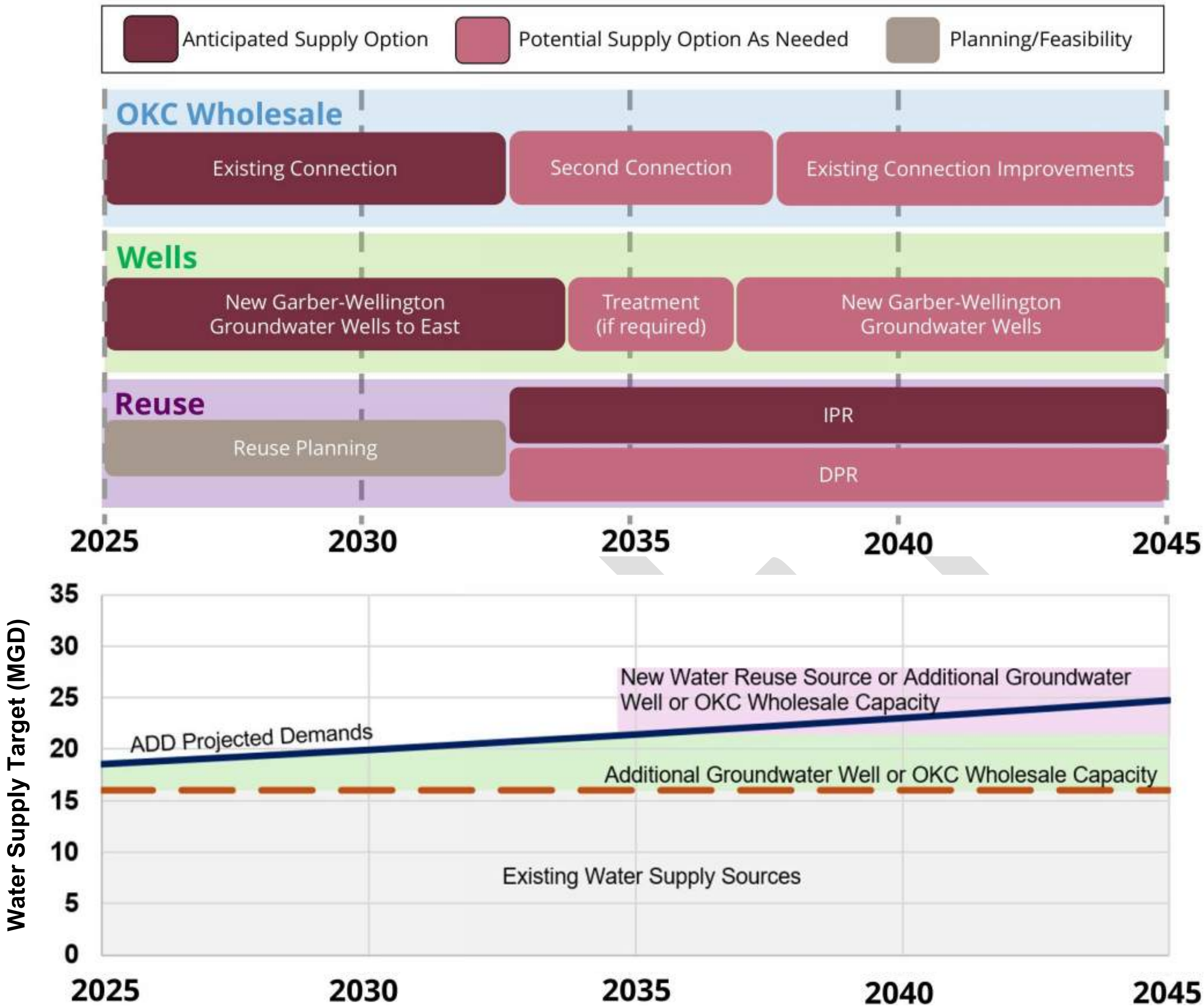
The results of the non-monetary and monetary scoring were used to select the final supply alternatives. It is recommended that NUA uses purchased water from OKC to meet an immediate increase in demands. Once the daily average volume needed exceeds 6 MGD, a second OKC connection will be necessary. New Garber-Wellington groundwater wells can also be constructed to minimize supply gaps. To meet the anticipated long-term supply gaps, it is recommended that either IPR or DPR be constructed. This phased approach will allow NUA to phase in new sources as necessary as demands increase.

12.4 WATER SUPPLY STRATEGIES

The implementation of new sources in the future will be based on the actual increase in future demands. This requires a flexible strategy to determine when implementation of new sources is necessary. Both the OKC and groundwater well options have been discussed at length in the above sections. A more in-depth summary related to the use of IPR and DPR can be found in the Reuse Evaluation Technical Memorandum which can be found in Appendix E.

A strategic approach to the implementation of new water sources is outlined in Figure 12-5. The approach allows NUA to determine which of the source options are available and feasible in both the short- and long-term. The strategy would adjust which supply alternatives are implemented based on changes to cost or feasibility of the alternative. This approach provides flexibility to adapt to increasing demands in real-time.

Figure 12-5: Water Supply Capacity Strategy Flow Chart



13.0 FUTURE SYSTEM ASSESSMENT

A future system assessment was completed to identify water system projects for the CIP. The hydraulic model was used evaluations at multiple future planning horizons (2030, 2035, 2040, 2045). The evaluation criteria used during the existing system assessment were also used for the assessment at future horizons. Those criteria can be found in Section 6.0. Evaluations and CIP recommendations are based on the anticipated development patterns and future demands.

However, the timeline discussed is based on the anticipated future demand and development patterns, and actual project construction/implementation will be based on actual new developments and demand increases.

13.1 FUTURE HYDRAULIC MODEL UPDATES

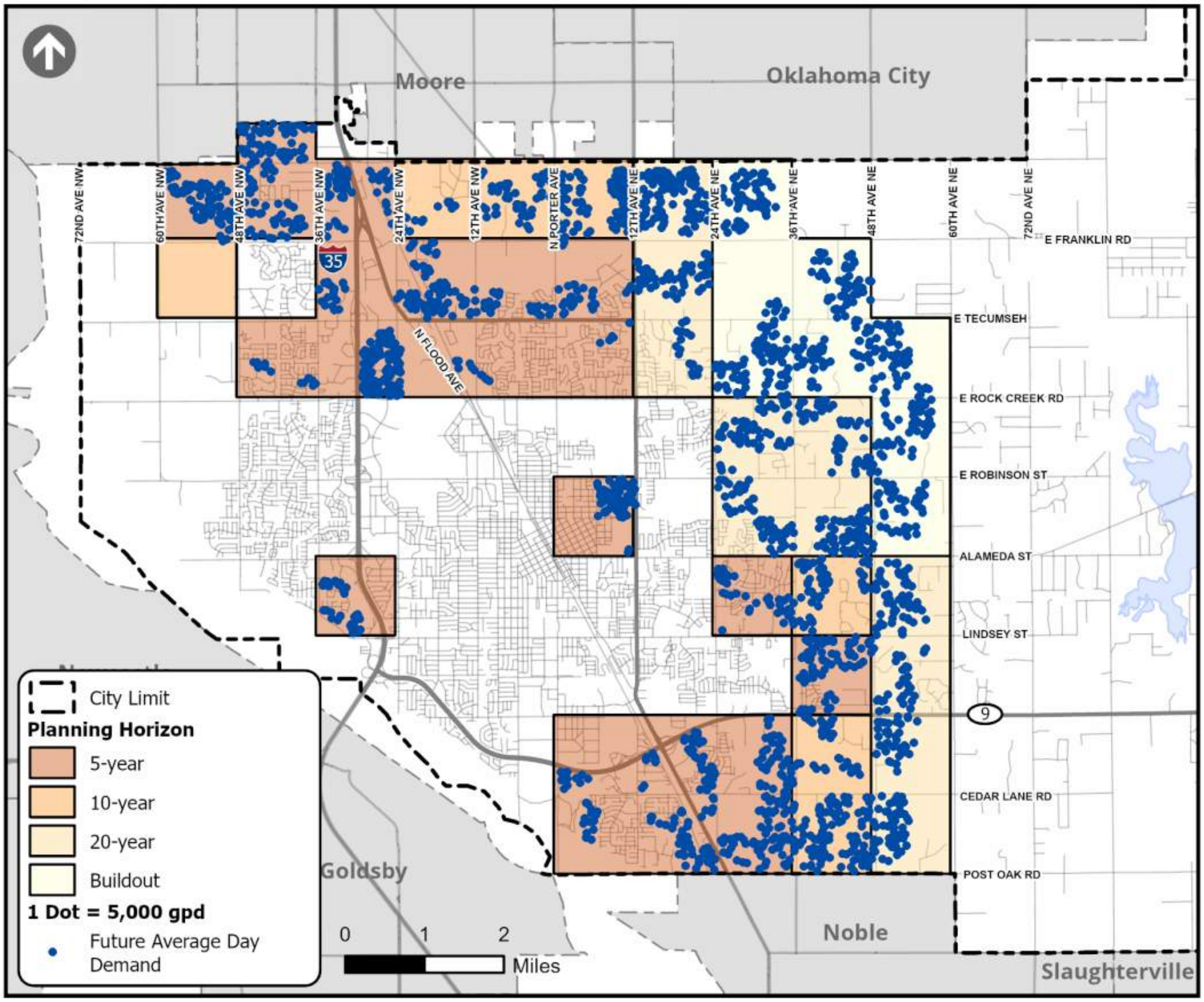
13.1.1 FUTURE LAND USE

Future flows were added to the model based on the future land use developed for the Norman Comprehensive Plan. These areas and their anticipated future land use classification are shown in Map 2-3 and Appendix B.

13.1.2 FUTURE DEMANDS

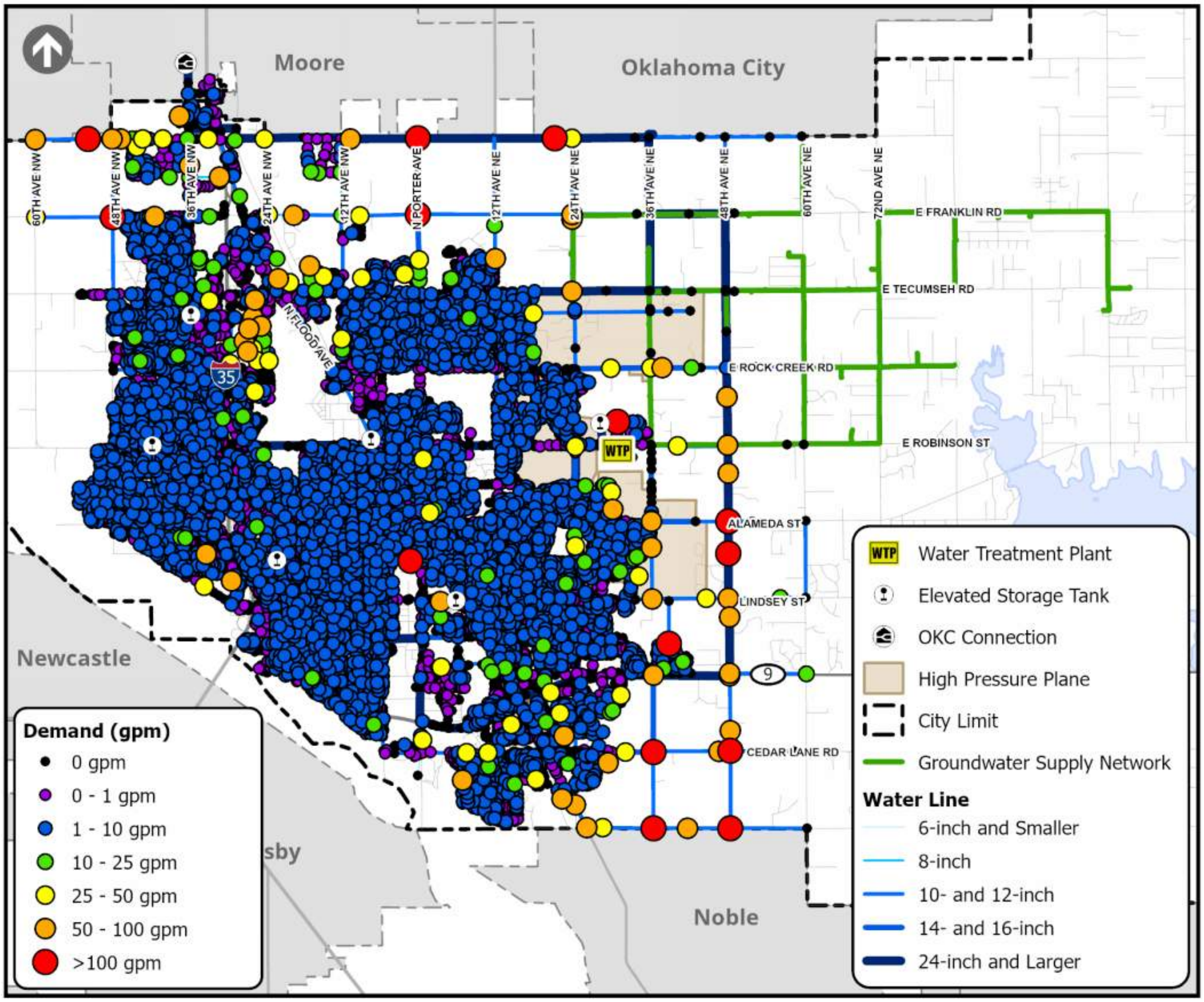
Future demands were allocated to planning horizons to match the overall average demand projections discussed in Section 4.0. As discussed in Section 4.0, ADD is expected to be 19.9 MGD in the 5-year horizon, 21.4 MGD in the 10-year horizon, and 24.7 MGD in the 20-year horizon. Starting with an existing ADD of 18.3 MGD, demands from the developable parcels were added until the target ADD for each horizon was reached. Developable parcels were allocated to the planning horizons in order of proximity to existing infrastructure, so that parcels that would be easiest to connect to the existing system or more likely to develop first are allocated to earlier horizons. Map 13-1 shows the allocation of the developable parcels to the planning horizons. Parcels not allocated to a planning horizon are not anticipated to be developed in the 20-year horizon but are considered in development of buildout flows used for infrastructure sizing.

Map 13-1: Developable Areas by Planning Horizon



Once the future land use was determined, future demands were allocated in the hydraulic model based on these land use classifications and the area of each development. The spatial distribution of future maximum day demands is shown in Map 13-2.

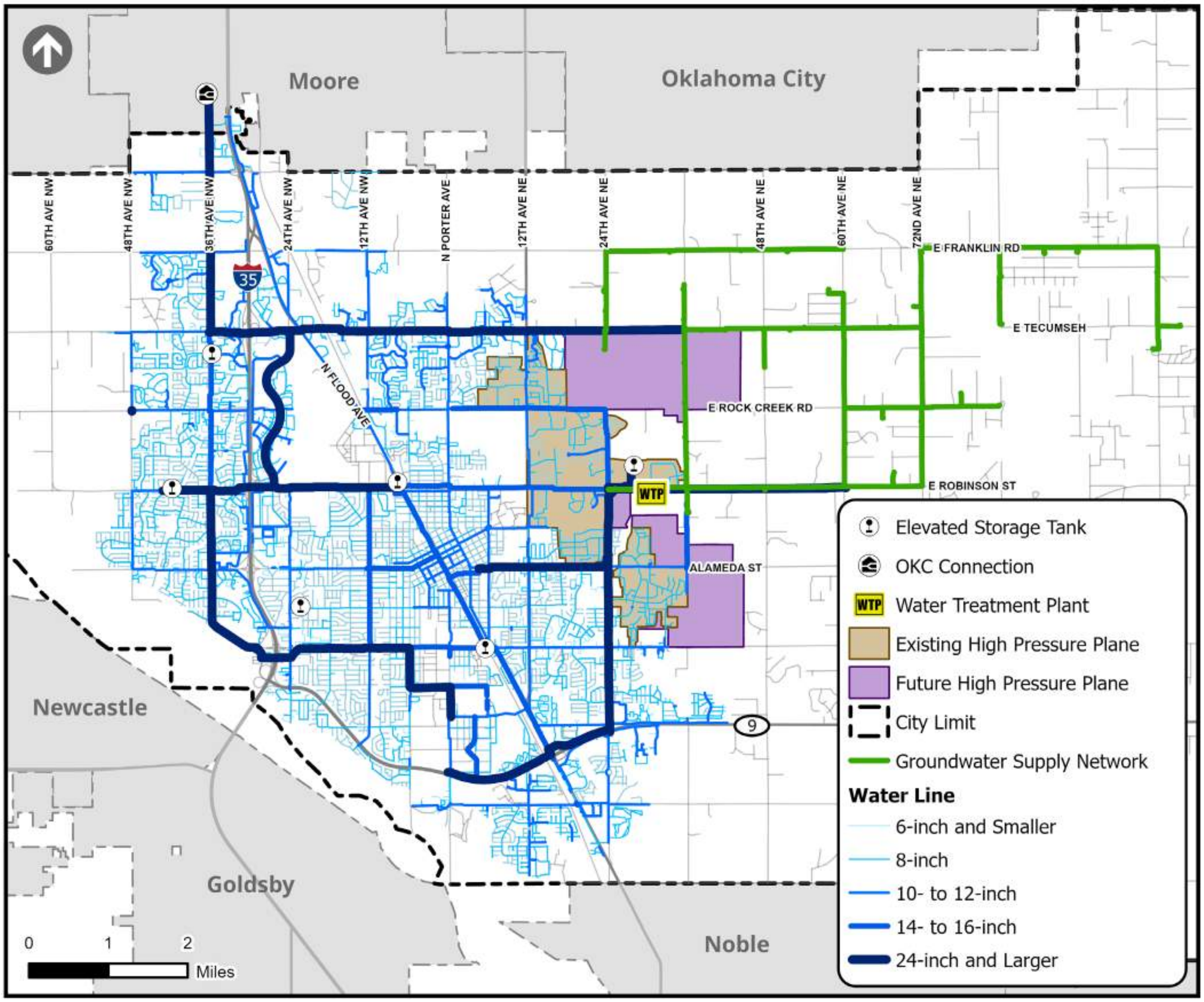
Map 13-2: Hydraulic Model Spatial Demand - Future Maximum Day Demand



13.1.3 FUTURE HIGH PRESSURE PLANE BOUNDARY

With the anticipated future land use and projected growth, it is expected that the HPP will be expanded primarily through developer extensions. The future HPP boundary identified by Garver is shown in Map 13-3.

Map 13-3: Future High Pressure Plane Boundary



13.2 SUPPLY CAPACITY ASSESSMENT

It is anticipated that by 2045, an additional 12 MGD (including 10% reserve capacity) of supply capacity will need to be added as discussed in Section 10.1. Figure 10-1 and Figure 10-2 show the projected average and maximum day supply gap under normal conditions. Figure 10-3 and Figure 10-4 show the potential decrease in capacity as a result of a reduction in surface water rights to Lake Thunderbird, which would ultimately increase the projected supply gaps.

For this future supply capacity assessment, the existing permitted withdrawal for Lake Thunderbird was used, as well as the previously presented volumes for the OKC connection and Garber-Wellington groundwater well capacity. Potential supply alternatives discussed in Section 11.2 were used to fill the remaining projected supply gap.

A phased approach is recommended that will allow for an increase in the usage of existing sources and then the addition of new sources, as necessary. This phased approach would allow NUA to meet the projected supply gap in the near-term by using existing sources while new sources and required infrastructure are constructed. New sources can then be phased in as they become available, ultimately giving NUA the flexibility to use existing sources and then supplement with new sources in the long-term as they are needed to meet the actual future demands.

Over the next 10 years, the existing sources can be incrementally increased as demands increase. An increase in the purchased wholesale supply from OKC and the usage of groundwater can be used as needed to meet increased demands. As demands continue to increase, one of the new reuse supply options discussed in Section 11.2 can be added to address supply gaps. However, if implementation of reuse is further delayed or becomes infeasible, NUA could increase supply form OKC or groundwater capacity to meet supply gaps. Table 13-1 summarizes how existing and new sources can be phased in to address supply gaps.

Table 13-1: Future Supply Capacity Assessment

Horizon	Supply Gap	Potential Supply Used to Meet Supply Gap		
		OKC	Groundwater	New Reuse (IPR or DPR)
5-Year (2030)	4 – 8 MGD	x	x	--
10-Year (2035)	6 – 9 MGD	x	x	--
20-Year (2045)	9 – 12 MGD	x	x	x
35-Year (2060)	15 – 18 MGD	x	x	x

13.3 STORAGE CAPACITY ASSESSMENT

As discussed in the existing system storage capacity assessment (Section 10.2), the total storage capacity is lower than one day of ADD. Additional storage tanks will be required to serve the future growth anticipated in the service area. Addressing storage deficiencies is a multi-year process to plan, design, and construct each new facility. New storage should be sized to cover storage requirements into the future for a reasonable horizon.

Table 13-2 presents the advantages and disadvantages of ESTs and ground storage tanks (GST). ESTs are likely to be the most beneficial distributed throughout the NUA distribution system as they tend to stabilize system pressures and would be less impacted by supply pumping operations. While GSTs require a pump station, they are advantageous from a capital cost perspective because they can be placed near existing pump stations. Multiple GSTs can be built over time at a single site to allow for phased development to allow the GST capacity to match the supply capacity at that location, preventing problems associated with excessive water age.

Table 13-2: Storage Type Considerations

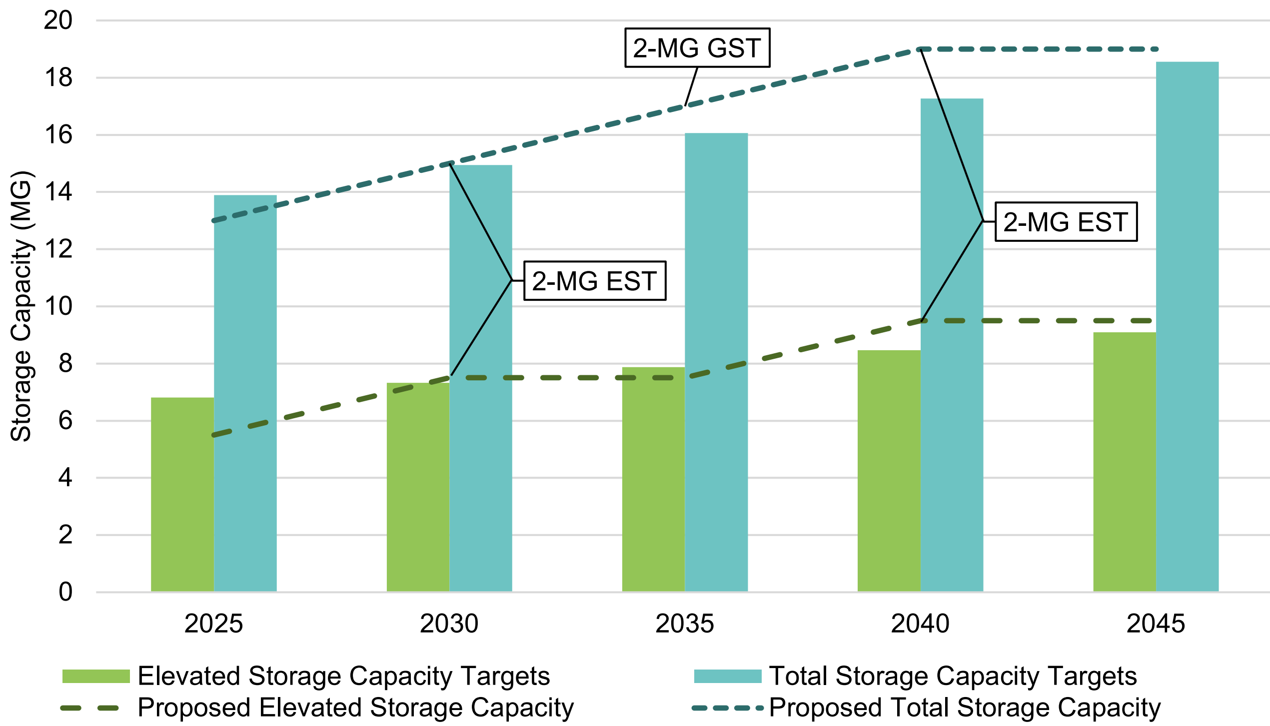
Storage Types	Advantages	Disadvantages

EST	• Stable system pressures
	• No re-pumping required
	  ○ More reliable
		• Highest construction cost
		• No local control over tank level
		  ○ Prone to low/high turnover
		• Generally, only cost effective up to 2 MG maximum
		• High visual impact

GST with Booster Pump	• Lower Construction Cost (for tank) • Larger sizes available/more cost effective • Easier to phase in additional storage (tank farm) • Large volumes/pump stations can be used to supplement WTP pump stations/transmission • Less visual impact	• Requires pump station ○ Construction/energy costs

A combination of multiple types of storage are typical in distribution systems and will most likely be the most ideal option, as each type supplies a specific advantage. To determine the total storage target capacity 75% of the projected ADD was used, and 20% of the MDD was used to determine the elevated storage target capacity. Figure 13-1 presents the target capacities for both the total and elevated storage and the proposed storage volume for each. It is anticipated that a total of 6 MG of total storage will need to be added, with at least 4 MG being elevated storage.

Figure 13-1: Future Storage Capacity Assessment



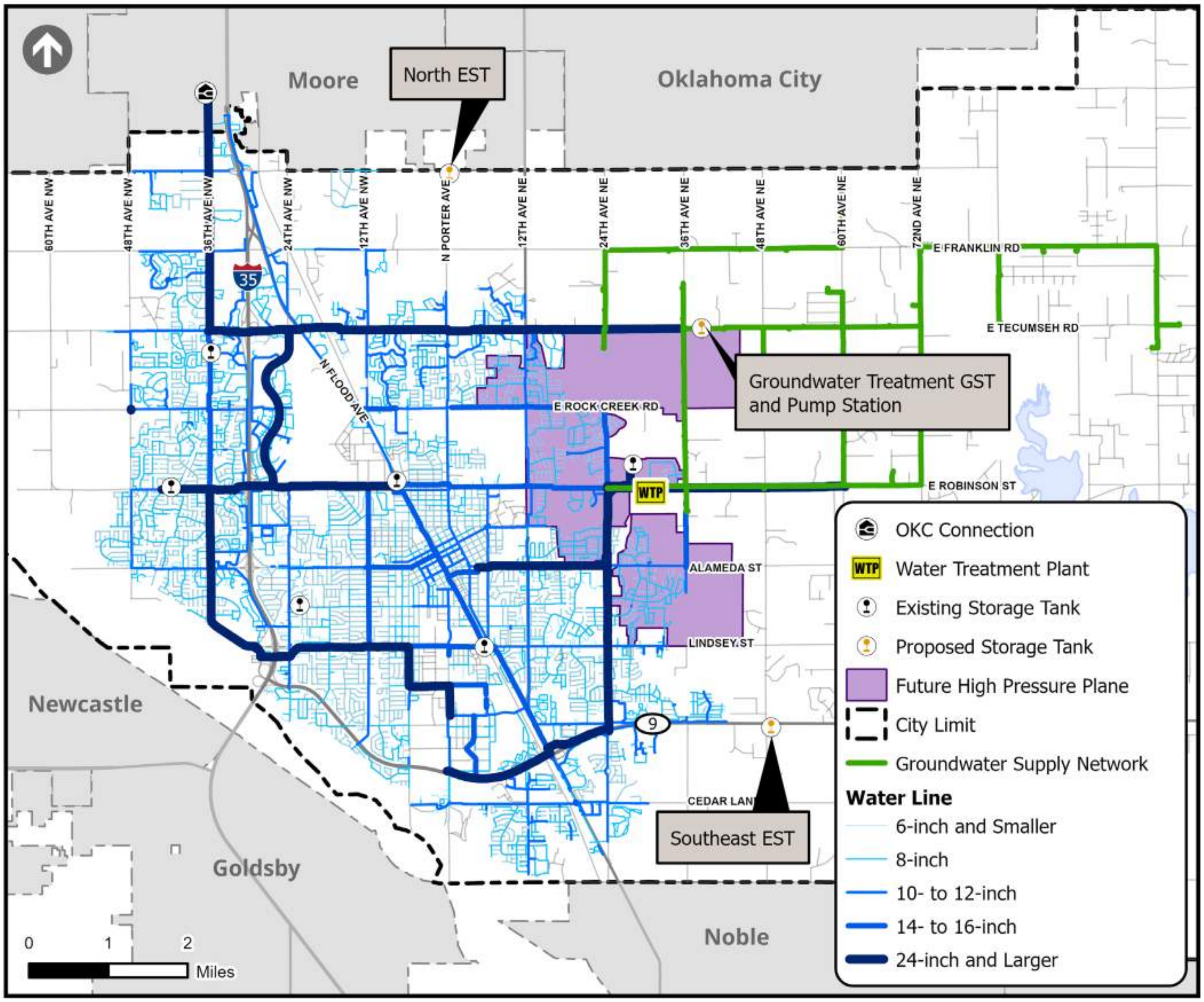
13.4 FUTURE SYSTEM IMPROVEMENTS

The existing hydraulic model was used to identify water distribution system improvements to address existing issues with transmission capacity and storage, as well as to determine improvements that would provide additional capacity to serve future growth. The future hydraulic model results for the 5-, 10-, and 20-year planning horizons are presented in Appendix G. Results for the 35-year planning horizon are not presented but were reviewed to verify the sizes needed for future projects.

It is anticipated that existing storage will be insufficient by 2030, and an additional 6 MG of storage will be necessary to meet future demands through the 2045 horizon. It is recommended to construct three additional storage tanks by 2045. Future land use and expected urban expansion suggest that new storage will be necessary to keep up with growth in the northeast and southeast portions of the system.

It is anticipated that a new EST in the southeast portion of the WSA will be necessary in the near-term to meet expected growth in the area. As urban expansion continues, it is anticipated that in the next 10 to 20 years an additional EST will be necessary in the northeast portion of the WSA. Additionally, a GST is expected to be added that will be associated with the groundwater WTP facility. The recommended locations of the additional storage tanks are shown in Map 13-4.

Map 13-4: Proposed Storage Improvements



It is also recommended that an additional OKC connection be added to serve growing demands in the northern portion of the system. The additional OKC connection will not only increase the flow volume into the system but also allow for better spatial distribution of water from this source.

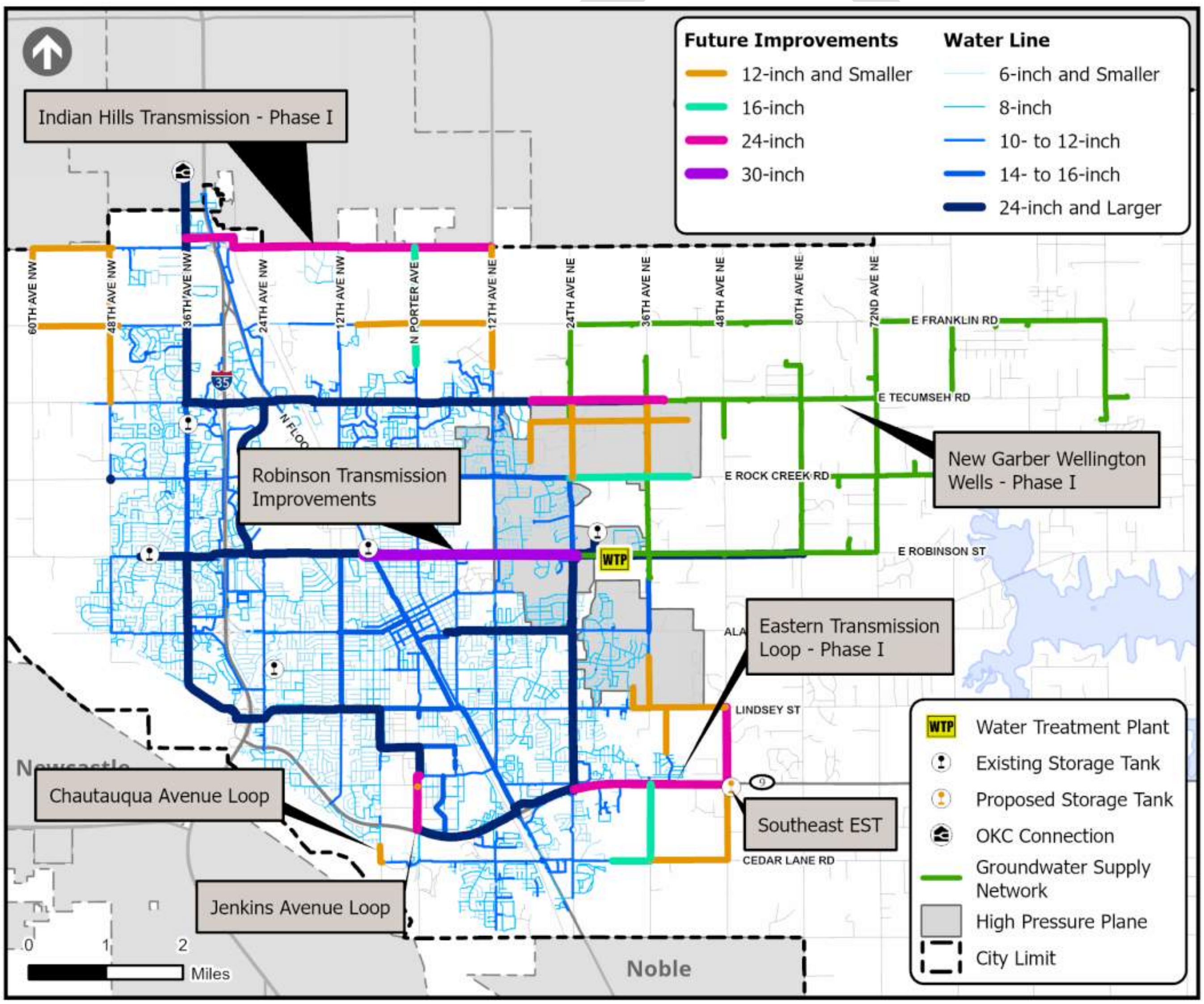
All proposed improvements identified for the water distribution system are listed in Table 13-3. All recommended improvements to transmission capacity and storage are illustrated in Map 13-5, Map 13-6, and Map 13-7. More details about these improvements are discussed in Section 14.0.

Table 13-3: Proposed Water Utility Improvements

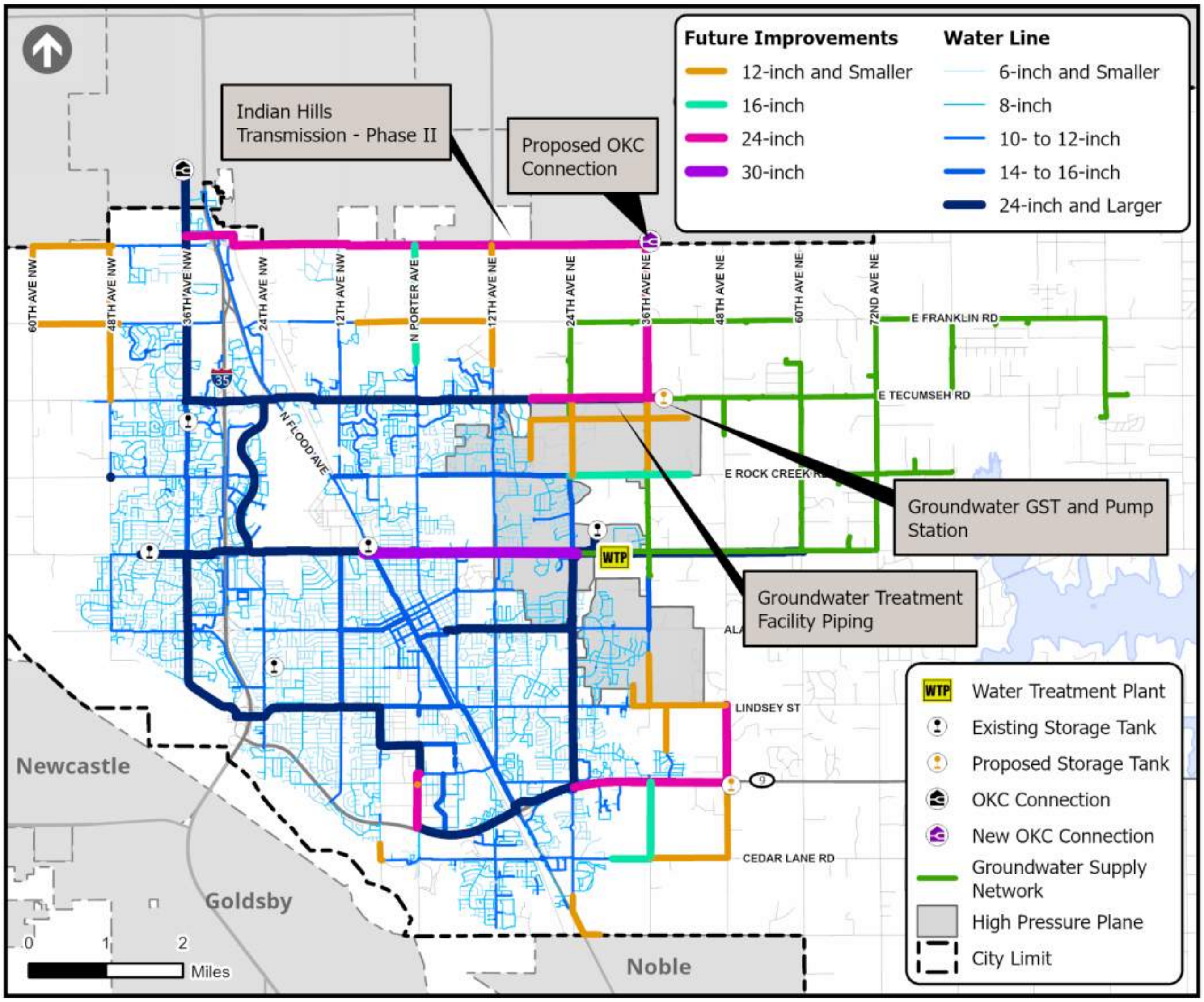
Horizon	Project Type	Project Name	Proposed Size
5-Year (2030)	Transmission	Chautauqua Loop	12-inch
	Transmission	Jenkins Loop	24-inch
	Storage	Southeast EST	2.0 MG
	Transmission	Indian Hills Transmission Loop Phase I	24-inch
	Transmission	Eastern Transmission Loop Phase I	24-inch
	Supply	New Garber-Wellington Wells Phase I	5.0 MGD

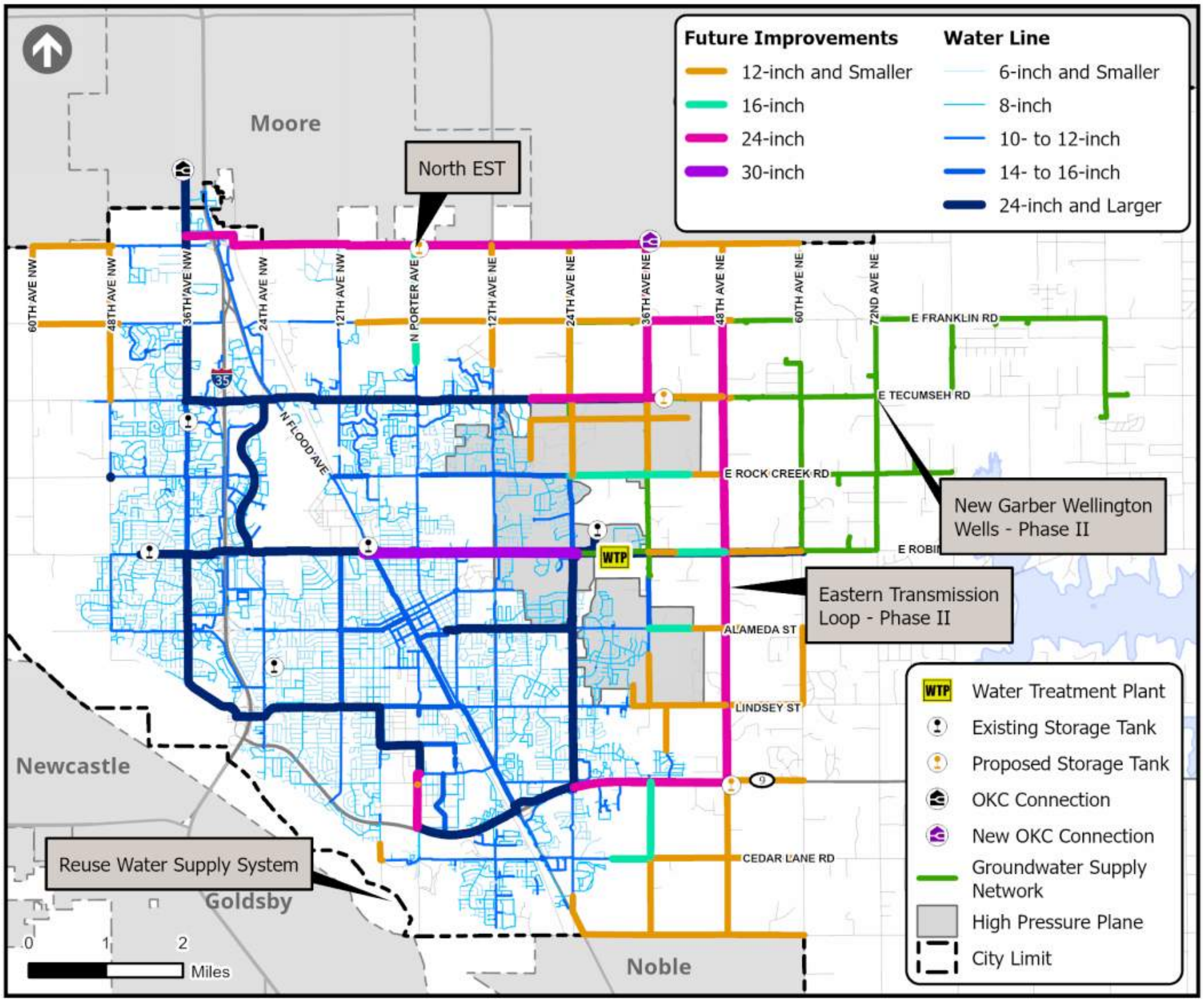
Horizon	Project Type	Project Name	Proposed Size
10-Year (2035)	Transmission	Robinson Transmission Main	30-inch
	Storage	Groundwater Treatment GST & Pump Station	2.0 MG
	Transmission	Groundwater Treatment Facility Piping to System	24-inch
	Supply	Second OKC Connection	24-inch
	Transmission	Indian Hills Transmission Loop Phase II	24-inch
20-Year (2045)	Transmission	Eastern Transmission Loop Phase II	24-inch
	Supply	New Garber-Wellington Wells Phase II	5.0 MGD
	Storage	North EST	2.0 MG
	Supply	Reuse Water Supply System	10.0 MGD

Map 13-5: 5-Year Planning Horizon Improvements



Map 13-6: 10-Year Planning Horizon Improvements




Future Improvements
12-inch and Smaller
16-inch
24-inch
30-inch
Water Line
6-inch and Smaller
8-inch
10- to 12-inch
14- to 16-inch
24-inch and Larger
Moore
North EST
60TH AVE NW
48TH AVE NW
36TH AVE NW
24TH AVE NW
12TH AVE NW
N PORTER AVE
12TH AVE NE
24TH AVE NE
36TH AVE NE
48TH AVE NE
60TH AVE NE
72ND AVE NE
E FRANKLIN RD
E TECUMSEH RD
E ROCK CREEK RD
N FLOOD AVE
35
New Garber Wellington Wells - Phase II
WTP
Eastern Transmission Loop - Phase II
ALAMEDA ST
LINDSEY ST
CEDAR LANE RD
9
Newcastle
Reuse Water Supply System
Goldsby
Noble
0
1
2
Miles
Water Treatment Plant
Existing Storage Tank
Proposed Storage Tank
OKC Connection
New OKC Connection
Groundwater Supply Network
High Pressure Plane
City Limit

14.0 CAPITAL IMPROVEMENTS PLAN

To better convey the anticipated flows from proposed new sources and improve existing system deficiencies a series of CIP projects were identified. Several projects were identified as part of a 20-year CIP with the intent of increasing supply, storage, and transmission capacity to accommodate future growth over the next 20 years. This section outlines the process used for CIP development and a summary of the identified projects.

14.1 PROJECT IDENTIFICATION AND TRIGGERS

Each project was prioritized based on project triggers or project justifications. Project triggers are described in Table 14-1 and listed in order of priority, from highest to lowest priority. Projects were prioritized and phased over the planning horizons based on occurrence of project triggers. In addition, flexibility was assigned to projects based on their prioritization and phasing, with highly flexible projects being able to potentially be moved to later dates. For example, a project with an operational trigger to address dead-end water lines that does not greatly affect service in the area will have high flexibility. In contrast, a project with a regulatory trigger phased to address an existing issue will have low flexibility.

Table 14-1: Project Triggers

Project Trigger	Project Type
Regulatory	This trigger is activated if regulatory requirements (e.g., minimum residual pressure, available fire flow, etc.) would not be met.
Capacity	This trigger is activated if additional supply, storage, or transmission capacity is needed to meet future system-wide peak demands.
Growth	This trigger is activated as a primary trigger if a line is an extension or loop required to serve new developments. This trigger is activated as a secondary trigger if a capacity improvement is required to serve additional demands.
Fire Flow	This trigger is activated if a portion of the system does not have available for fire flows that meet or exceed minimum required fire flow rates.
Condition	This trigger is activated based on deteriorating conditions of existing infrastructure, as identified during field investigations. Field investigations were limited to above grade infrastructure. As such, the condition trigger was not applied to any buried linear infrastructure.
NUA Directed	This trigger is activated when NUA staff have identified that items will be replaced, are required as part of upcoming policy changes, or are needed to manage growth.
Operational	This trigger is activated when an improvement will provide an operational benefit. An example would be looping and dead-end requirements that would improve water quality and minimize flushing.

14.2 PROJECT TIMELINES

Project priorities were assigned based on the identified triggers to establish the recommended project order for an overall timeline to meet the anticipated planning horizon. Each project has also been assigned a flexibility rating of low, medium, or high. Projects with higher flexibility can be deferred until later in the planning horizon, depending on the available funding or changing system conditions that would impact the need for the project (such as unexpected delays in development that delay the need for capacity improvements).

The threshold date is the year the existing capacity of the system would be exceeded without the proposed project. Start dates were selected based on the anticipated project duration to achieve completion before the threshold date.

The start date is then used to capture anticipated costs for the life of the project by escalating the total estimated 2024 costs at a rate of 3% per year.

14.3 COST DEVELOPMENT

Cost estimates were prepared for each individual project based on industry standards and the 2024 bidding environment. These costs are an estimate and should be re-evaluated as each project nears its start date. Each project has the following costs associated with the total project cost estimate:

- Construction Cost/Bid Items
- Easement Acquisition
- Engineering Design/Professional Services

The cost estimates included in this CIP are Class 4 estimates as defined by the Association for the Advancement of Cost Engineering (AACE), which is consistent with cost estimates developed for studies. The methodologies used for Class 4 estimates are summarized in Section 12.2.

14.3.1.1 CONSTRUCTION COSTS

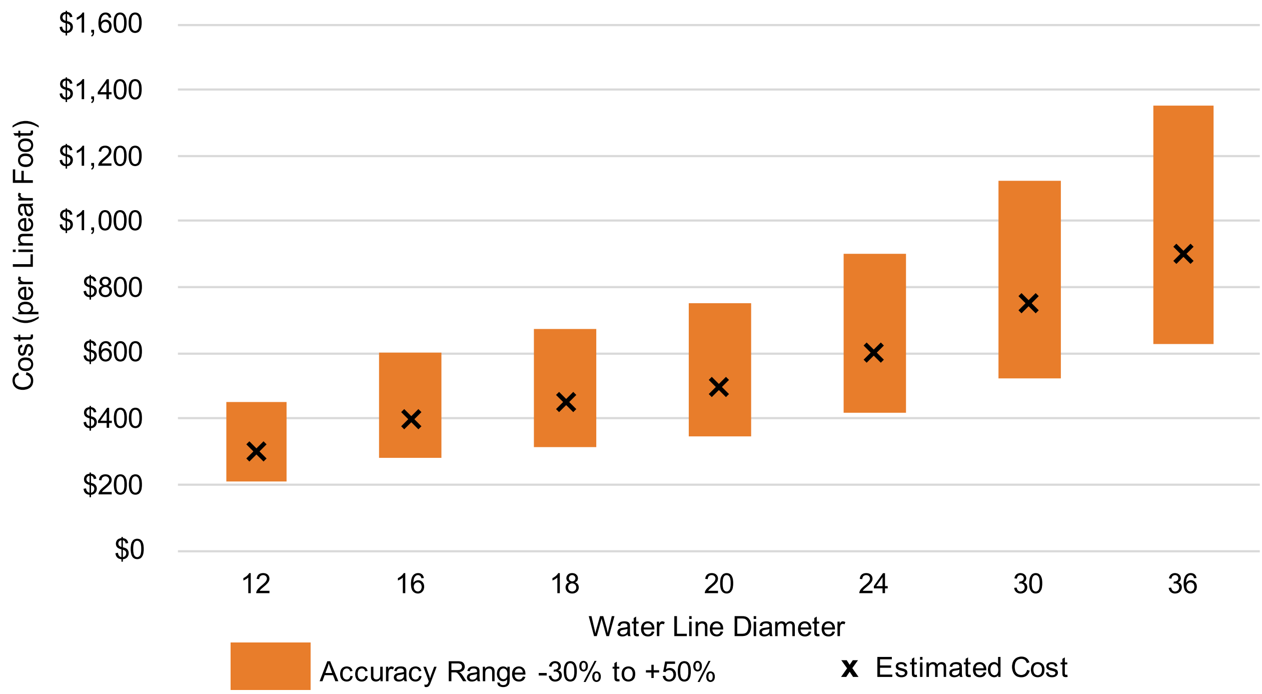
Construction cost is the estimated cost once the project has been designed and is ready for the bid phase to begin. The construction costs are comprised of bid items and include a construction cost contingency of 30%.

Costs for water lines, tanks, and pumping facilities were calculated as described in the following sections. Individual bid items are described as follows:

- **Electrical:** Anticipated material costs for electrical equipment associated with new pumps, wiring, conduit, rehab of existing buildings, new electrical associated with new buildings, and SCADA integration
- **General Improvements:** Anticipated sitework, backfill, erosion control, rehabilitation of existing structures, and testing
- **Unforeseen Construction Costs:** Cost for anticipated service connections and connections to existing pipes, including isolation valves. This cost is assumed to be approximately 5% of the construction subtotal
- **Water Line Installation:** Material, labor, and contractor's overhead costs associated with pipe installation on a linear footage basis depending on the water line size

Water line costs have been estimated based on $25/inch diameter/linear foot unit costs, presented in Figure 14-1. Costs are based on similar facilities completed by Garver. Cost estimates related to stream crossings have been estimated by doubling the water line unit costs. Cost estimates related to bored road crossings are based on bids from recent projects reviewed by Garver. The actual project costs will vary based on a variety of factors, including the amount of asphalt and concrete repair; number, length, and type of crossings (creeks, roads, railroads, etc.); and pipe material and pressure class. Soil characteristics in the project area were also considered.

Figure 14-1: Construction Cost Estimation for Water Lines



Storage tank costs have been estimated based on proposed storage type (ground/elevated), tank volume, tank type and historical experience with similar projects. Storage tank cost estimates include tank mixing systems. Actual project costs will vary based on a variety of factors, including piping requirements, site grading, foundation requirements, baffling or mixing desired, and architectural treatment for the tank exterior.

14.3.1.2 PROFESSIONAL SERVICES

The engineering estimate includes all professional services needed to bid each project including survey, deed research (as needed), preliminary design, final design of all improvements, and construction phase services. The cost, based on the total estimated construction costs with contingency included, is assumed to be 25% for facilities projects (reuse, treatment, or pump station), 20% for water line projects, and 10% for storage tank projects.

14.3.1.3 EASEMENT ACQUISITION

The engineering estimate includes easement acquisitions needed to bid each project, including coordination of land acquisition and land value. The cost is assumed to be 10% of the construction subtotal including 30% contingency. This includes additional easements for tank sites.

14.4 CIP SUMMARY

The methodology used to develop the 5-, 10-, 20-, and 35-year CIP has been discussed above. The project prioritization and cost estimates for proposed improvements are presented in Table 14-2. An overview map of the CIP projects is shown in Map 14-1.

Table 14-2: 20-Year CIP Cost Summary

Project Number	Existing WSA Improvements	Anticipated Date of Project	Estimated Project Cost (2024 Dollars)
1	Chautauqua Loop: 12-inch	2025	$0.7M
2	Jenkins Loop: 24-inch	2026	$4.0M
3	Robinson Transmission Main: 30-inch	2030	$19.5M
		Existing WSA Improvements Subtotal	**$24.2M**
Project Number	**Future WSA Improvements**	**Anticipated Date of Project**	**Estimated Project Cost (2024 Dollars)**
4	Southeast Elevated Storage Tank (EST)	2027	$15.3M
5a, 5b	Eastern Transmission Loop: 24-inch	2027 & 2035	$51.4M
6a, 6b	Indian Hills Transmission Loop: 24-inch	2028 & 2033	$45.8M
7	GW Treatment Ground Storage Tank (GST) & Pump Station	2032	$15.3M
8	GW Treatment Facility Piping to System: 24-inch	2032	$9.6M
9	North EST	2038	$15.3M
		Future WSA Improvements Subtotal	**$152.7M**
Project Number	**Supply Improvements**	**Anticipated Date of Project**	**Estimated Project Cost (2024 Dollars)**
10a, 10b	New Garber-Wellington Wells	2029 & 2036	$65.5M
11	Second OKC Connection	2033	$23.3M
12	Reuse Water Supply System	2034	$350.0M
		Supply Improvements Subtotal	**$438.8M**
		Improvements Total	**$615.7M**

Map 14-1: 20-Year CIP Summary

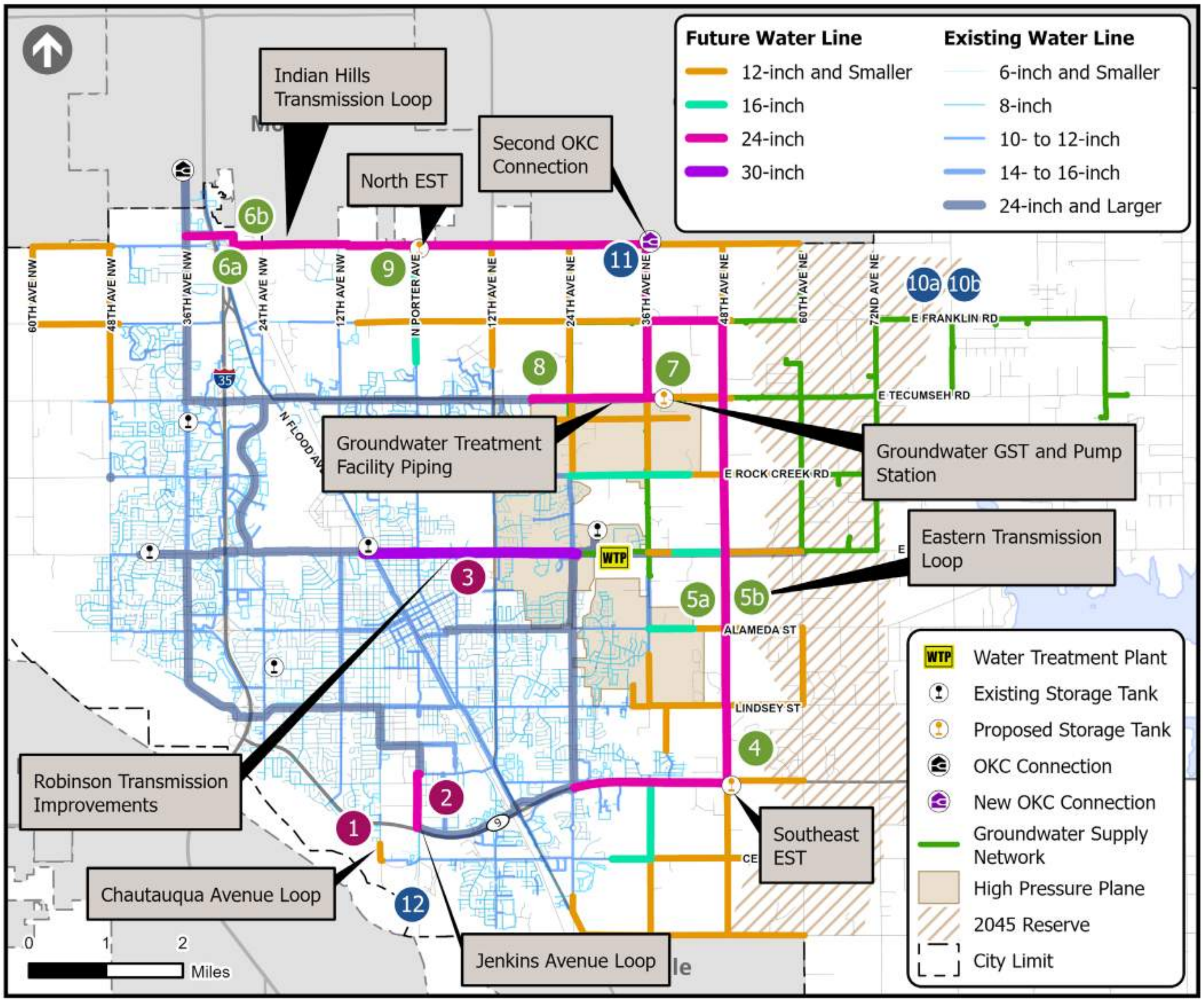


Figure 14-2 and Figure 14-3 summarize the proposed project schedule and proposed spending schedule with 30% construction cost contingency to complete the CIP projects. The full cost estimates for each CIP project can be found in Appendix H. Table 14-4 and Table 14-5 summarize the project details described in the following sections.

Figure 14-2: Proposed Capital Outlay Schedule

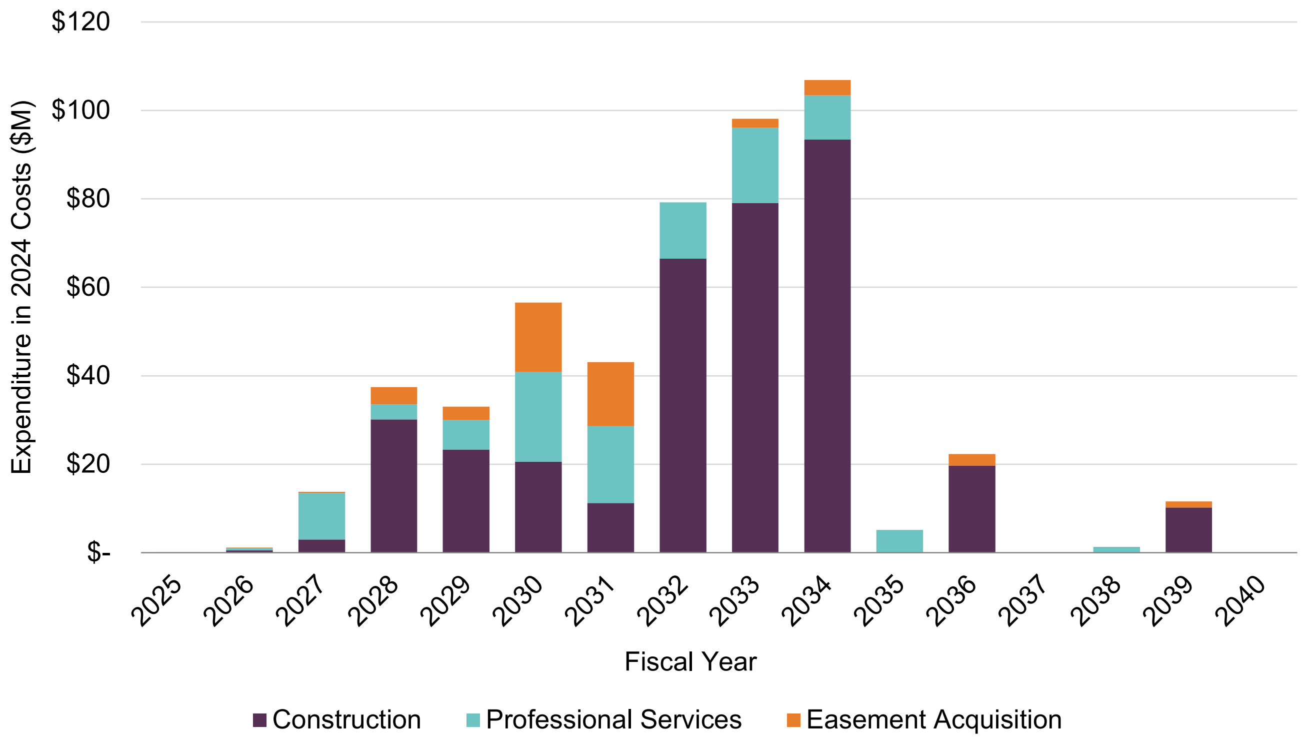
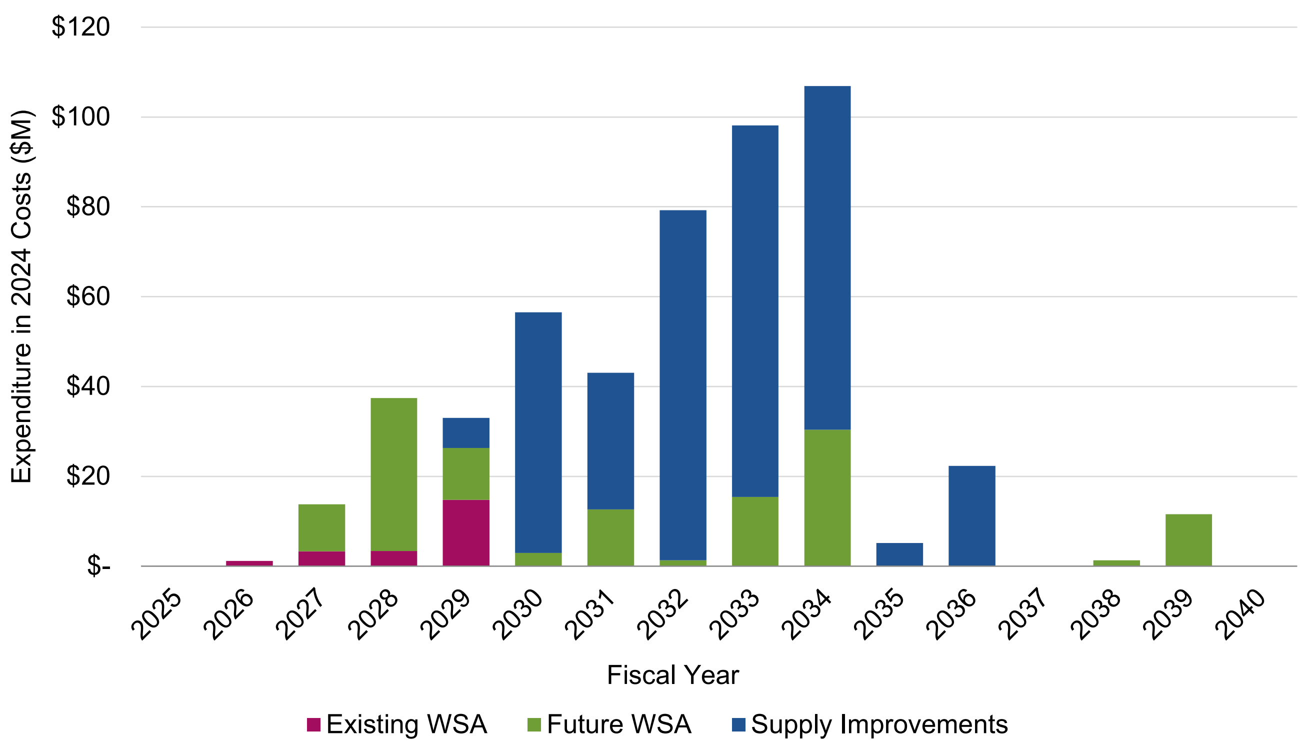


Figure 14-3: Proposed Capital Outlay Schedule by Project Type



Specific CIP projects will need to be constructed to convey increased flows due to the increase in capacity of existing sources. Similarly, new sources will also require the construction of specific CIP projects. Table 14-3 summarizes the CIP projects necessary to convey the needed flows from each source.

Table 14-3: Water Supply Strategy Sources and Associated CIP Projects

Source	Associated CIP Project
Existing OKC Connection	Indian Hills Transmission Loop Phase I
Second OKC Connection	Indian Hills Transmission Loop Phase II
Groundwater Wells	Groundwater GST and Pump Station
Reuse	Robinson Transmission Main

Table 14-4: Water CIP Project Details

Project Identification				Project Schedule							
Project	Description	Location	Flexibility	Primary Trigger	Secondary Trigger	Capacity Threshold	Threshold Year	Start Date	Project Complete	Total Project Duration (months)
1	Chautauqua Loop	Chautauqua Avenue	High	Operational	N/A	N/A	N/A	1/1/2025	2027	30
2	Jenkins Loop	South Jenkins Avenue	Medium	Capacity	Operational	N/A	N/A	1/1/2026	2028	30
3	Robinson Transmission Main	East Robinson Road from Robinson Tank to 24th Avenue Northeast	Medium	Capacity	Growth	N/A	N/A	1/1/2030	2032	30
4	Southeast Elevated Storage Tank	Highway 9 and 48th Avenue Southeast	Medium	Growth	Capacity	ADD = 20 MGD MDD = 37 MGD	2035	1/1/2027	2030	36
5a	Eastern Transmission Loop Phase I	48th Avenue Northeast from East State Highway 9 to Lindsey Street	Medium	Growth	Capacity	N/A	N/A	1/1/2027	2029	30
5b	Eastern Transmission Loop Phase II	48th Avenue Northeast from Lindsey Street to Franklin Road	Medium	Growth	Capacity	N/A	N/A	1/1/2035	2037	30
6a	Indian Hills Transmission Loop Phase I	West Indian Hills Road from 36th Avenue Northwest to 12th Avenue Northeast	Medium	Growth	Capacity	N/A	N/A	1/1/2028	2030	30
6b	Indian Hills Transmission Loop Phase II	West Indian Hills Road from12th Avenue Northeast to 36th Avenue Northeast	Medium	Growth	Capacity	N/A	N/A	1/1/2033	2035	30
7	Groundwater Treatment Ground Storage Tank & Pump Station	East Tecumseh Road from Via Circle to 38th Avenue Northeast	Medium	Growth	Capacity	ADD = 21 MGD MDD = 39 MGD	2030	1/1/2032	2034	30
8	Groundwater Treatment Facility Piping to System	East Tecumseh Road and 36th Avenue Northeast	Medium	Growth	Capacity	ADD = 21 MGD MDD = 39 MGD	2030	1/1/2032	2034	30
9	North Elevated Storage Tank	West Indian Hills Road and North Porter Avenue	Medium	Growth	Capacity	ADD = 25 MGD MDD = 42 MGD	2045	1/1/2038	2040	30
10a	New Garber-Wellington Wells Phase I	Eastern Portion of Municipal Boundary	Medium	Growth	Capacity	N/A	N/A	1/1/2027	2029	30
10b	New Garber-Wellington Wells Phase II	Eastern Portion of Municipal Boundary	Medium	Growth	Capacity	N/A	N/A	1/1/2029	2031	30
11	Second OKC Connection	East Indian Hills Road and 36th Avenue Northeast	Medium	Growth	Capacity	Purchased Volume from OKC=6 MGD	2035	1/1/2033	2035	30
12	Reuse Water Supply System	Existing WRF (Jenkins Avenue and West State Highway 9)	Medium	Growth	Capacity	N/A	N/A	1/1/2030	2036	72

Table 14-5: Water CIP Project Costs

Project	Description	2024 Costs				Forecasted Costs				
		Professional Services	Easement Acquisition	Construction with 30% Cost Contingency	Total Project Cost	Forecasted Year	Professional Services	Easement Acquisition	Construction with 30% Cost Contingency	OPCC
1	Chautauqua Loop	$99,000	$50,000	$494,000	$643,000	2027	$102,000	$52,000	$525,000	$679,000
2	Jenkins Loop	$600,000	$300,000	$2,996,000	$3,896,000	2028	$637,000	$319,000	$3,274,000	$4,230,000
3	Robinson Transmission Main	$2,916,000	$1,458,000	$14,579,000	$18,953,000	2032	$3,482,000	$1,741,000	$17,931,000	$23,154,000
4	Southeast Elevated Storage Tank	$1,333,000	$1,333,000	$13,325,000	$15,991,000	2030	$1,457,000	$1,457,000	$14,998,000	$17,912,000
5a	Eastern Transmission Loop Phase I	$2,482,000	$1,241,000	$12,406,000	$16,129,000	2029	$2,713,000	$1,357,000	$13,964,000	$18,034,000
5b	Eastern Transmission Loop Phase II	$5,132,000	$2,566,000	$25,659,000	$33,357,000	2037	$7,104,000	$3,552,000	$36,584,000	$47,240,000
6a	Indian Hills Transmission Loop Phase I	$3,398,000	$1,699,000	$16,990,000	$22,087,000	2030	$3,825,000	$1,913,000	$19,697,000	$25,435,000
6b	Indian Hills Transmission Loop Phase II	$3,412,000	$1,706,000	$17,058,000	$22,176,000	2035	$4,452,000	$2,226,000	$22,925,000	$29,603,000
7	Groundwater Treatment Ground Storage Tank & Pump Station	$1,333,000	$1,333,000	$13,325,000	$15,991,000	2034	$1,689,000	$1,689,000	$17,387,000	$20,765,000
8	Groundwater Treatment Facility Piping to System	$1,421,000	$711,000	$7,105,000	$9,237,000	2034	$1,801,000	$901,000	$9,271,000	$11,973,000
9	North Elevated Storage Tank	$1,333,000	$1,333,000	$13,325,000	$15,991,000	2040	$2,017,000	$2,017,000	$20,760,000	$24,794,000
10a	New Garber-Wellington Wells Phase I	$6,682,000	$2,673,000	$26,728,000	$36,083,000	2029	$7,302,000	$2,921,000	$30,083,000	$40,306,000
10b	New Garber-Wellington Wells Phase II	$6,682,000	$2,673,000	$26,728,000	$36,083,000	2031	$7,747,000	$3,099,000	$31,915,000	$42,761,000
11	Second OKC Connection	$3,586,000	$1,793,000	$17,930,000	$23,309,000	2035	$4,679,000	$2,340,000	$24,097,000	$31,116,000
12	Reuse Water Supply System	$64,837,000	$25,935,000	$259,347,000	$350,119,000	2036	$77,419,000	$30,968,000	$328,534,000	$436,921,000

14.5 5-YEAR CIP IMPROVEMENTS

The 2030 CIP projects are driven by the constraints of the existing water distribution system that were identified during the existing system assessment and the anticipated growth in the projected development areas. The following projects are proposed to improve operations and increase capacity:

- A new 12-inch water line is proposed along Chautauqua Avenue to create a loop with existing 8- and 12-inch water lines along Chautauqua Avenue and Bratcher Miner Road, respectively.
- A new 24-inch water line is proposed along South Jenkins Avenue to create a loop with existing 24-inch water lines along East State Highway 9 and South Jenkins Avenue.
- A new 30-inch transmission main along Robinson Street is recommended to improve transmission capacity between the existing Robinson Tank and the Vernon Campbell WTP.
- The proposed 2.0 MG Southeast EST near East State Highway 9 and 48th Avenue will meet the existing storage capacity deficit within the distribution system.
- The recommended Phase I of the Eastern Transmission Loop will construct the southern portion of the transmission project.
- The recommended Phase I of the Indian Hills Transmission Loop is proposed between 36th Avenue Northwest and 12th Avenue Northeast to increase transmission capacity from the existing OKC connection to the eastern portion of the system.
- Phase I of the New Garber-Wellington Wells with a capacity of 5.0 MGD is recommended to increase the supply available to NUA.

14.6 10-YEAR CIP IMPROVEMENTS

The 2035 CIP projects are driven by the anticipated growth in the projected development areas previously discussed. The primary impacts of these improvements will be increasing transmission and supply capacity near the projected growth areas. These projects can be added on a needed basis as expansion occurs in real-time; based on projected growth, it is anticipated that these projects will be needed around 2035. The following projects are proposed to address the projected system constraints:

- The proposed 2.0 MG Groundwater Treatment GST near East Tecumseh Road and 36th Avenue Northeast is recommended to meet the existing storage deficit. This project will also require the installation of a new pump station and additional water lines to convey water from this location into the distribution system.
- The installation of a second OKC connection will be necessary once the average daily purchase volume from OKC exceeds 6 MGD, which is anticipated to occur around 2035.
- The recommended Phase II of the Indian Hills Transmission Loop will continue the transmission project and will also serve as a connection between the second OKC connection and the existing WTP.

14.7 20-YEAR CIP IMPROVEMENTS

The 2045 CIP projects are driven by further anticipated growth in the projected development areas, and the primary impacts of these improvements will be increasing transmission, storage, and supply capacity. These projects can be added on a needed basis as expansion occurs in real-time. The following projects are proposed to address the projected system constraints:

- The recommended Phase II of the Eastern Transmission Loop will finish the northern portion of the transmission loop which will ultimately connect to the Indian Hills Transmission Loop.
- Phase II of the New Garber-Wellington Wells with a capacity of 5.0 MGD is recommended to increase the supply available to NUA.
- A new 2.0 MG North EST is proposed to address the projected storage deficit within the distribution system.
- A new Reuse Water Supply System is recommended to increase the supply available to NUA.

14.8 CORE REDEVELOPMENT

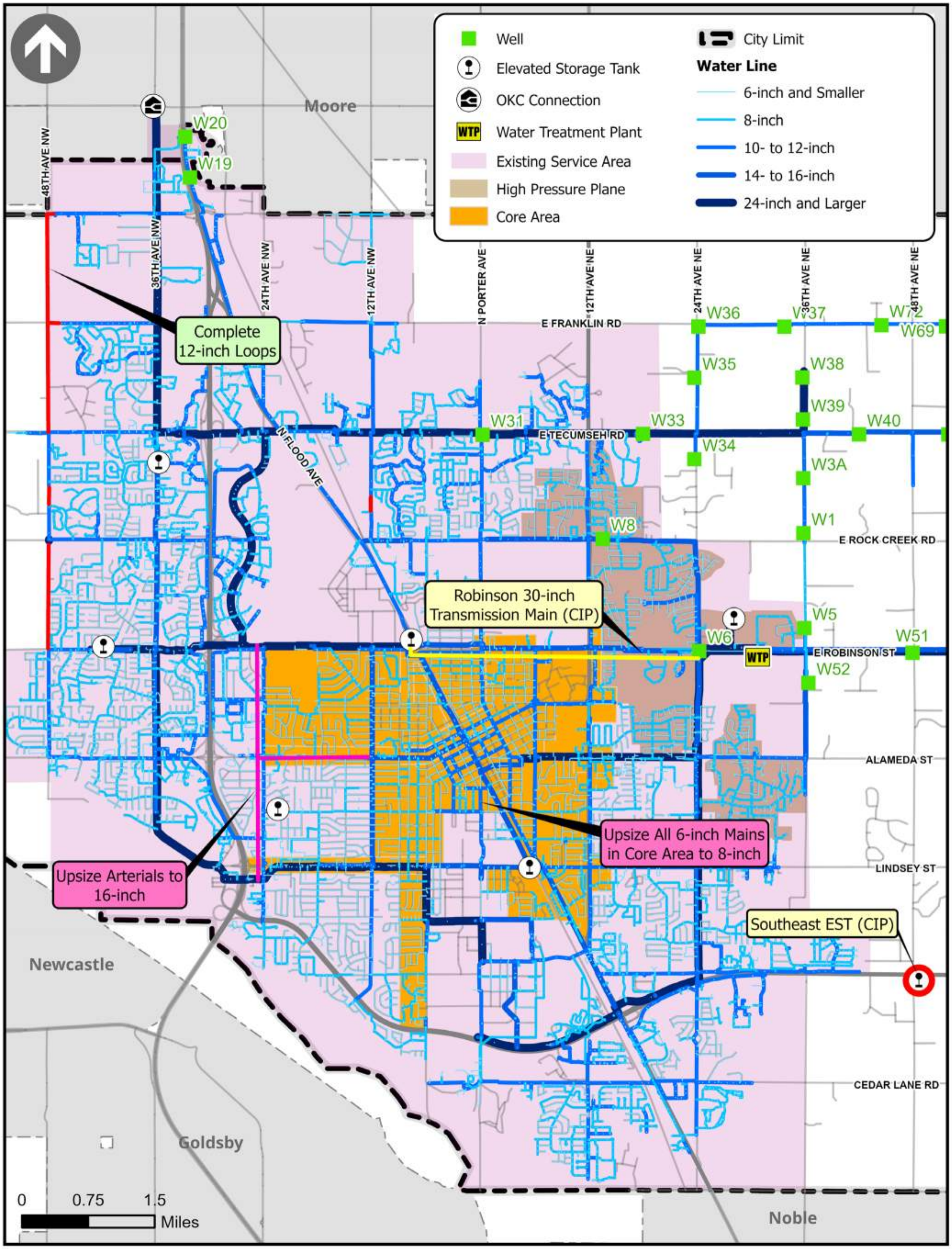
NUA staff identified an area of Norman that is already developed but is likely to redevelop. The area to be potentially redeveloped is referred to as the "core" area. The core area can be seen on Map 14-1. A scenario was created in the hydraulic model to represent the core area being redeveloped at a higher density. To be conservative, Garver applied the highest water demand per acre value established in Table 3-3 to the core area.

The highest water demand per acre value established in Table 3-3 was 2,700 gpd/acre. This value was scaled up by a max day peaking factor of 1.8 for a final rate of 4,860 gpd/acre. Assuming it would take many years for the core area to redevelop to such a high density, these scaled up core demands were applied to the 2045 scenario. The core area in the original 2045 scenario had a demand of 6.9 MGD, while the scaled-up core area demand is 19.1 MGD.

Because this core redevelopment scenario is set in 2045, the 20-year CIP improvements are active. In addition to the 20-year CIP improvements, all of the 6-inch pipes within the core area were upsized to 8-inch, select arterial roads with mains smaller than 16-inches were upsized to 16-inch, and new 12-inch pipes were installed north of the core area to improve transmission from the northern portion of the system down to the core area. These improvements are shown in Map 14-1.

If the core area were to be redeveloped prior to 2045, some CIP improvements would need to be constructed prior to their previously specified 5-, 10-, and 20-year triggers. Supply improvements will be needed in proportion with the demand increase, along with the transmission and storage CIP improvements shown in Map 14-1. If the redevelopment were to occur in the core area without constructing the specified improvements, the system supply, storage, and transmission would not be able to meet the increased core demands.

Map 14-2: Core Redevelopment Improvements

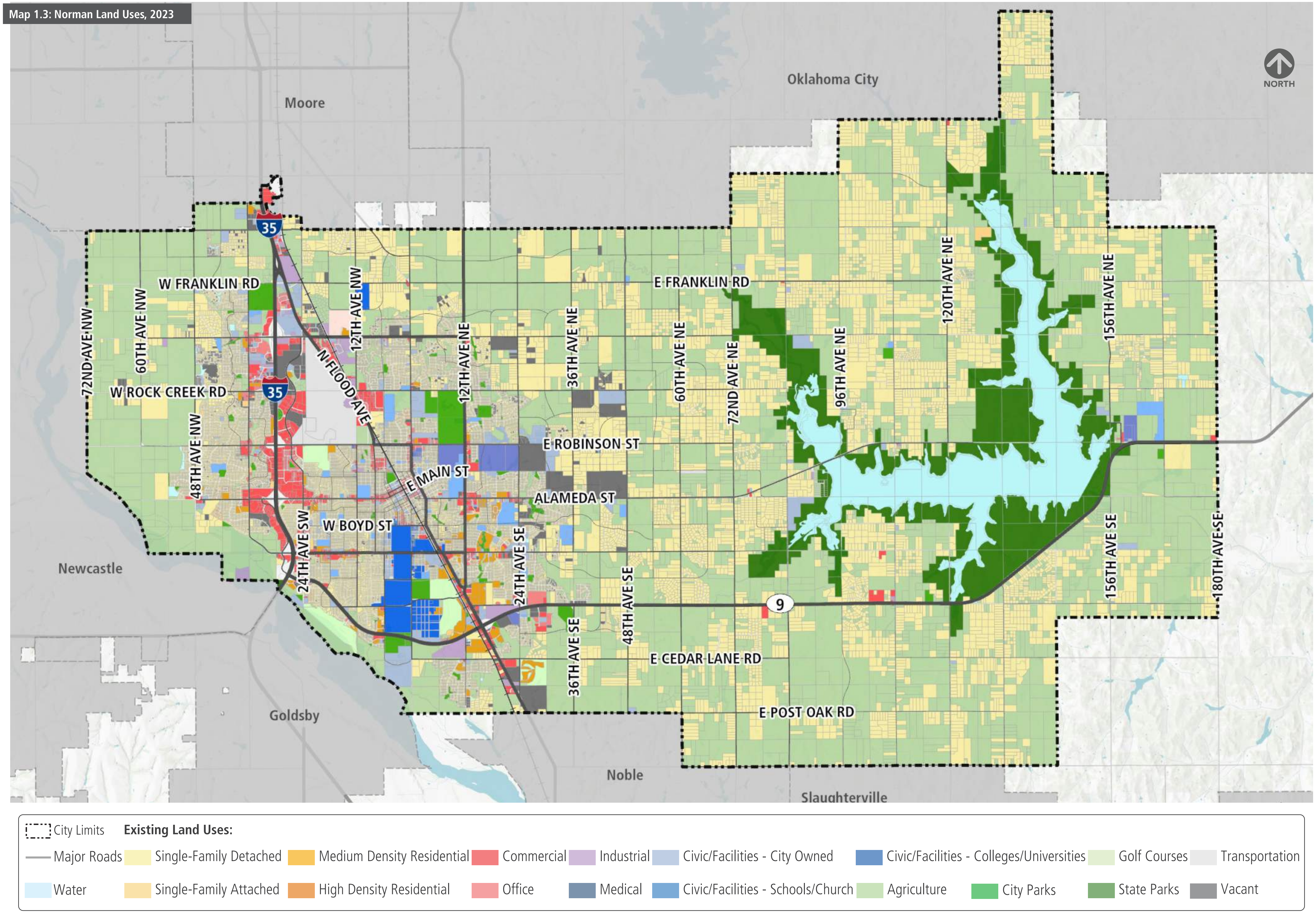


APPENDIX A

EXISTING LAND USE CLASSIFICATION

AIM NORMAN AREA & INFRASTRUTURE MASTER PLAN - NORMAN TODAY

PAGE 8



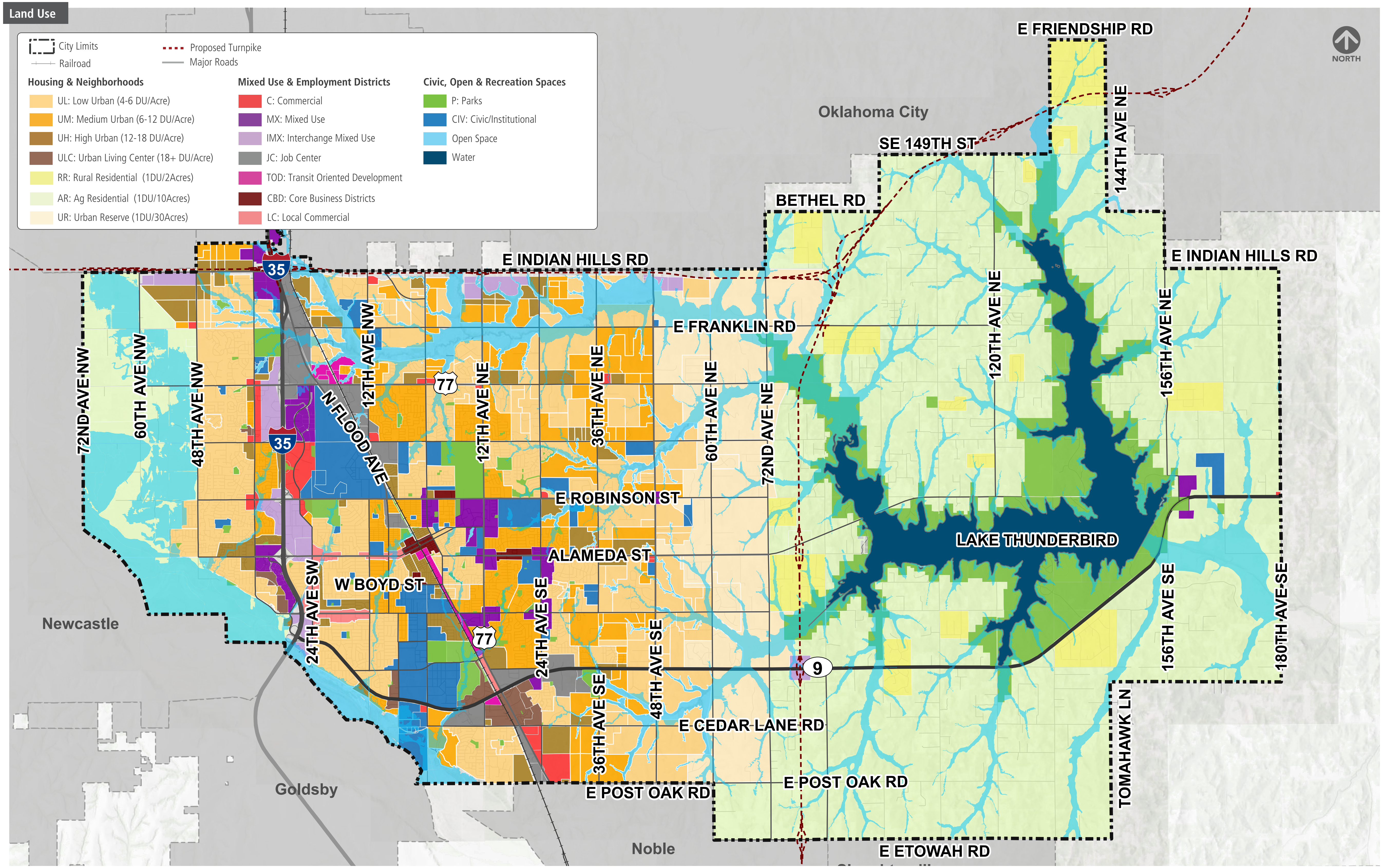
Source: City of Norman; UrbanFootprint (2023)

APPENDIX B

FUTURE LAND USE CLASSIFICATION

AIM NORMAN COMPREHENSIVE PLAN

PAGE 51



Land Use
City Limits
Railroad
Proposed Turnpike
Major Roads
Housing & Neighborhoods
UL: Low Urban (4-6 DU/Acre)
UM: Medium Urban (6-12 DU/Acre)
UH: High Urban (12-18 DU/Acre)
ULC: Urban Living Center (18+ DU/Acre)
RR: Rural Residential (1DU/2Acres)
AR: Ag Residential (1DU/10Acres)
UR: Urban Reserve (1DU/30Acres)
Mixed Use & Employment Districts
C: Commercial
MX: Mixed Use
IMX: Interchange Mixed Use
JC: Job Center
TOD: Transit Oriented Development
CBD: Core Business Districts
LC: Local Commercial
Civic, Open & Recreation Spaces
P: Parks
CIV: Civic/Institutional
Open Space
Water
NORTH
E FRIENDSHIP RD
Oklahoma City
SE 149TH ST
144TH AVE NE
BETHEL RD
E INDIAN HILLS RD
E INDIAN HILLS RD
E FRANKLIN RD
120TH AVE NE
156TH AVE NE
72ND AVE NW
60TH AVE NW
48TH AVE NW
12TH AVE NW
N FLOOD AVE
12TH AVE NE
36TH AVE NE
60TH AVE NE
72ND AVE NE
35
77
E ROBINSON ST
LAKE THUNDERBIRD
ALAMEDA ST
W BOYD ST
24TH AVE SW
24TH AVE SE
48TH AVE SE
156TH AVE SE
180TH AVE SE
Newcastle
9
E CEDAR LANE RD
36TH AVE SE
TOMAHAWK LN
E POST OAK RD
E POST OAK RD
Goldsby
Noble
E ETOWAH RD

APPENDIX C

FIELD DATA COLLECTION PLAN AND DATA SHEETS

GARVER
750 SW 24th St.
Suite 200
Moore, OK 73160
TEL 405.329.2555
FAX 405.329.3555
www.GarverUSA.com

MEMORANDUM

Date: April 3, 2024

To: Norman Utilities Authority

From: Josef Dalaeli, P.E.

RE: City of Norman Area & Infrastructure Master Plan – Water Field Data Collection Plan (Garver Project No. 22W02320, Norman Project No. WA0385)

The purpose of this memo is to propose a field data collection plan, which will be used to assess the accuracy and any needed calibration of the water distribution system hydraulic model. Additional field data collection may be required, depending on the level of calibration required to achieve sufficient model accuracy.

1.0 Continuous Pressure Monitoring

Pressure loggers will be installed at multiple locations to record variations in system pressure. Three of the loggers will be installed near supply points of entry to record boundary conditions for the system throughout the pressure monitoring and flow testing periods. The remaining loggers will be installed in three groups:

- Main Pressure Plane north of Robinson Street
- Main Pressure Plane south of Robinson Street
- High Pressure Plane

These loggers will be installed for approximately a week at each set of locations to record system pressures and collect data during nearby flow tests. The attached Exhibit 1 shows an overview of the logger locations, and each group is shown in more detail in the attached Exhibits 2–4.

Norman Utilities crew assistance is required for pressure logger installation and removal. Garver staff can download data from the loggers as needed.

1.1 Equipment and Personnel

Garver will provide the following:

- Six standard cellular pressure loggers
- Four transient cellular pressure loggers
- Accessories to download data from the loggers
- Two staff members to operate the pressure loggers

Norman Utilities will provide the following:

- One hydrant wrench
- One valve key
- One to two crew members to operate hydrants and install pressure loggers and diffusers on 2½-inch hydrant nozzles

1.2 Pressure Logger Procedures

The following procedure should be taken for each logger location:

1. Locate test pressure logger hydrant. Take photos of the hydrant.
2. Estimate discharge path for hydrant flushing and establish traffic control (if necessary).
3. Prior to installing each pressure logger, flush the hydrant to remove potential sediment build-up.
4. Install the pressure logger on the hydrant. Open the hydrant slowly and confirm the hydrant is not leaking.
5. Confirm the pressure logger is measuring pressure within the expected range.
6. Install locked cover on pressure logger.
7. After the recording period, ensure that the final round of data has been downloaded from the recorder.
8. Close hydrant.
9. Rotate pressure logger and ensure pressure is relieved before removing.

2.0 Flow Testing

The proposed locations for hydrant flow testing are shown on the attached exhibits. The test locations have been spread out across the distribution system to provide multiple calibration points and capture variations in pipe material, diameter, and year of installation. Site locations have been selected to balance the value of calibration data with potential community impacts (e.g., downstream drainage, traffic control, and public perception). The flow test locations are primarily in areas that were not tested in 2016. Alternative sites may be used if a proposed site is inaccessible or otherwise unsuitable.

Flow tests will be completed in multiple rounds corresponding to the pressure logger deployment groups discussed in Section 1.0 to provide additional information on the system response during the flow tests. The attached Exhibit 1 shows an overview of the flow test locations, and each flow test group is shown in more detail in the attached Exhibits 2–4. Vicinity maps for each flow test site are attached after the map exhibits.

2.1 Equipment and Personnel

Garver will provide the following:

- One 2½-inch pitot flow test diffuser with a pressure logger to measure the pitot gauge pressure
- Two residual pressure loggers
- Accessories to download data from the loggers

- Two staff members to operate the pressure loggers

Norman Utilities will provide the following:

- One hydrant wrench
- One valve key
- One 2½ -inch pitot flow test diffuser (if available)
- Two crew members to operate hydrants and install pressure loggers and diffusers on 2½ -inch hydrant nozzles

2.2 Definitions

The following definitions relate to the hydrant flow testing:

- Static Conditions – No hydrants open for flow testing
- Residual Conditions – One or more hydrant(s) open for flow testing
- Test (Residual) Hydrant – The hydrant where pressure will be recorded during the flow test
- Flow Hydrant(s) – The hydrant(s) that will be opened during a particular flow test and where flow will be recorded; multiple flow hydrants may be required to produce sufficient flow to obtain the desired pressure drop

2.3 Desired Pressure Drop

Table 1 summarizes the pressure drops that are generally desired for model calibration based on industry standards. Some flow test locations where significant pressure drops are not expected have been selected to confirm system operations.

Table 1: Desired Pressure Drop Values

Static Pressure	Desired Pressure Drop (DP)
P ≥ 40 psi	DP ≥ 10 psi
P < 40 psi	DP ≥ P/4
Note: During hydrant flow testing, flows should be limited so that system pressures equal to or exceeding the regulatory minimum (25 psi) are maintained throughout the system.	

2.4 Coordination with Field Personnel

The following items should be considered during field data collection:

- Valve Closure – All hydrant valves should be closed slowly in order to minimize impacts related to water hammer/hydraulic transients.

- Adjacent Property – During the hydrant flow testing process, significant flow rates and total volumes of water may be discharged from hydrants. It is important to assess where flow will be directed, natural drainage pathways, and whether or not a diffuser is necessary. Care should be taken to limit potential damage to nearby property (including parked vehicles and property downstream of the discharge location) and potentially hazardous conditions for pedestrian, bicycle, and motorized vehicle traffic.

2.5 Time/SCADA Synchronization and Recording

During each reading, all information displayed on the attached flow testing field data collection sheet should also be recorded from the SCADA system.

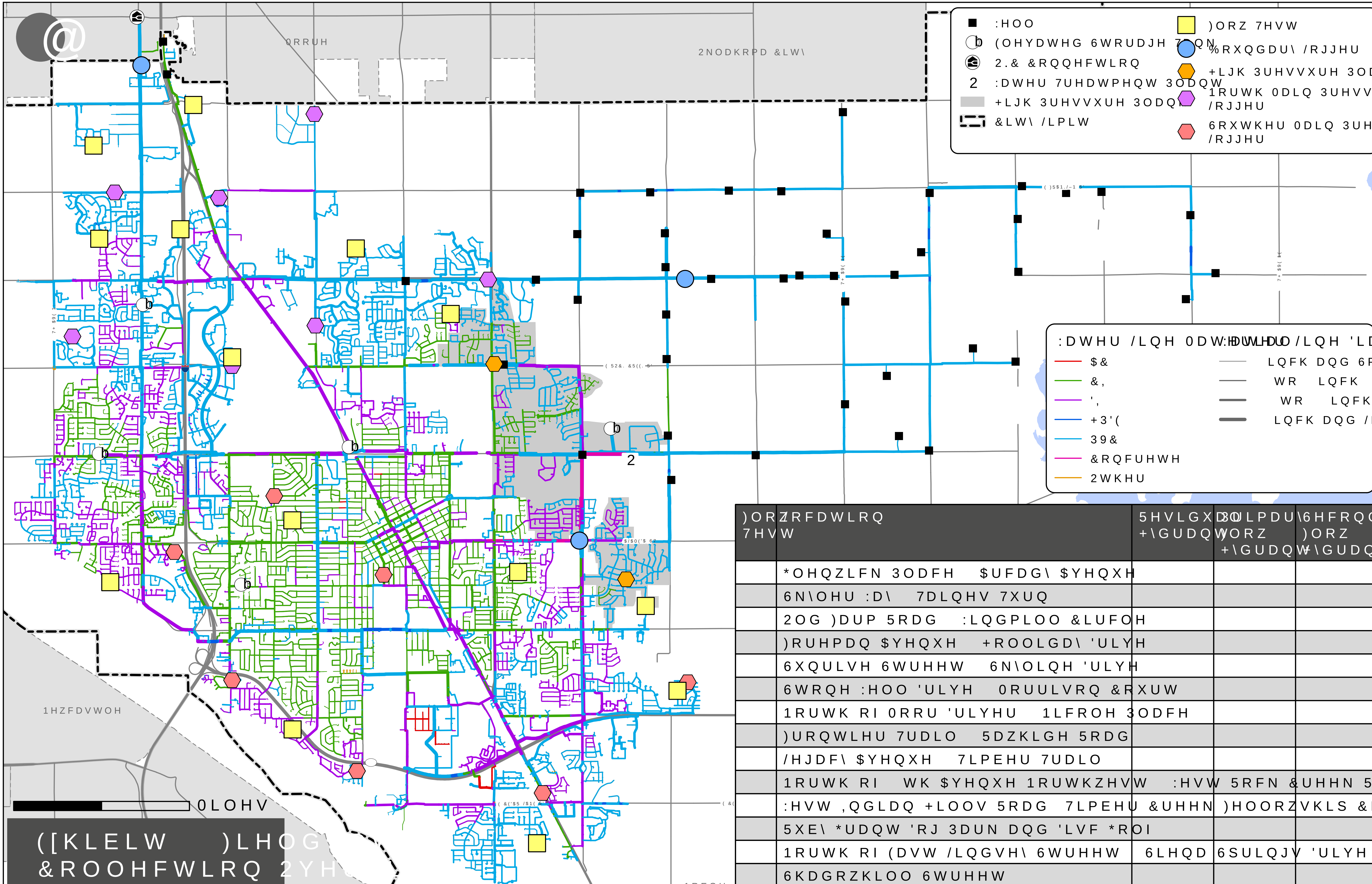
2.6 Fire Hydrant Flow Procedures

Gauges should be checked regularly and recalibrated as necessary, and gauges with different orifice sizes may be necessary to collect accurate flow data. Enclosed flow testing field data collection sheet will be used to document the required information.

The following procedure should be taken for each test:

1. Locate Test (residual) Hydrant and Flow Hydrant(s). Take photos of each hydrant.
2. Estimate discharge path for flow from each hydrant and establish traffic control (if necessary).
3. Prior to installing any gauges or flow meters, flush each hydrant to remove potential sediment build-up.
4. Install the residual pressure logger on the Test Hydrant. Open the hydrant slowly and confirm the hydrant is not leaking.
5. Record the static pressure at the Test Hydrant.
6. Install flow diffuser with pitot gauge at Flow Hydrant #1.
7. Record all required SCADA information immediately prior to beginning test.
8. Open Flow Hydrant #1 slowly and record flow.
9. While Flow Hydrant #1 is open, record the pressure reading on the Test Hydrant.
10. Slowly close Flow Hydrant #1.
11. Determine if the desired pressure drop occurred.
12. If the desired pressure drop occurred, the test is complete. If the desired drop did not occur, complete the remaining steps.
13. Install a second flow diffuser with pitot gauge at Flow Hydrant #2.
14. Open Flow Hydrants #1 and #2 slowly.
15. Record the flows at each hydrant with both flowing simultaneously.
16. Record the residual pressure at the Test Hydrant while both flow hydrants are open.
17. Slowly close both flow hydrants.
18. Record the static pressure at the Test Hydrant used during the test.

After testing is complete, field personnel should verify that all valves are closed properly (i.e., not seeping or leaking) and that the hydrants are ready for service.



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	6N\OHU :D\ 7DLQHV 7XUQ			
	2OG)DUP 5RDG :LQGPLOO &LUFOH			
	)RUHPDQ $YHQXH +ROOLGD\ 'ULYH			
	6XQULVH 6WUHHW 6N\OLQH 'ULYH			
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	1RUWK RI 0RUU 'ULYHU 1LFROH 3ODFH			
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	/HJDF\ $YHQXH 7LPEHU 7UDLO			
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	5XE\ *UDQW 'RJ 3DUN DQG 'LVF *ROI			
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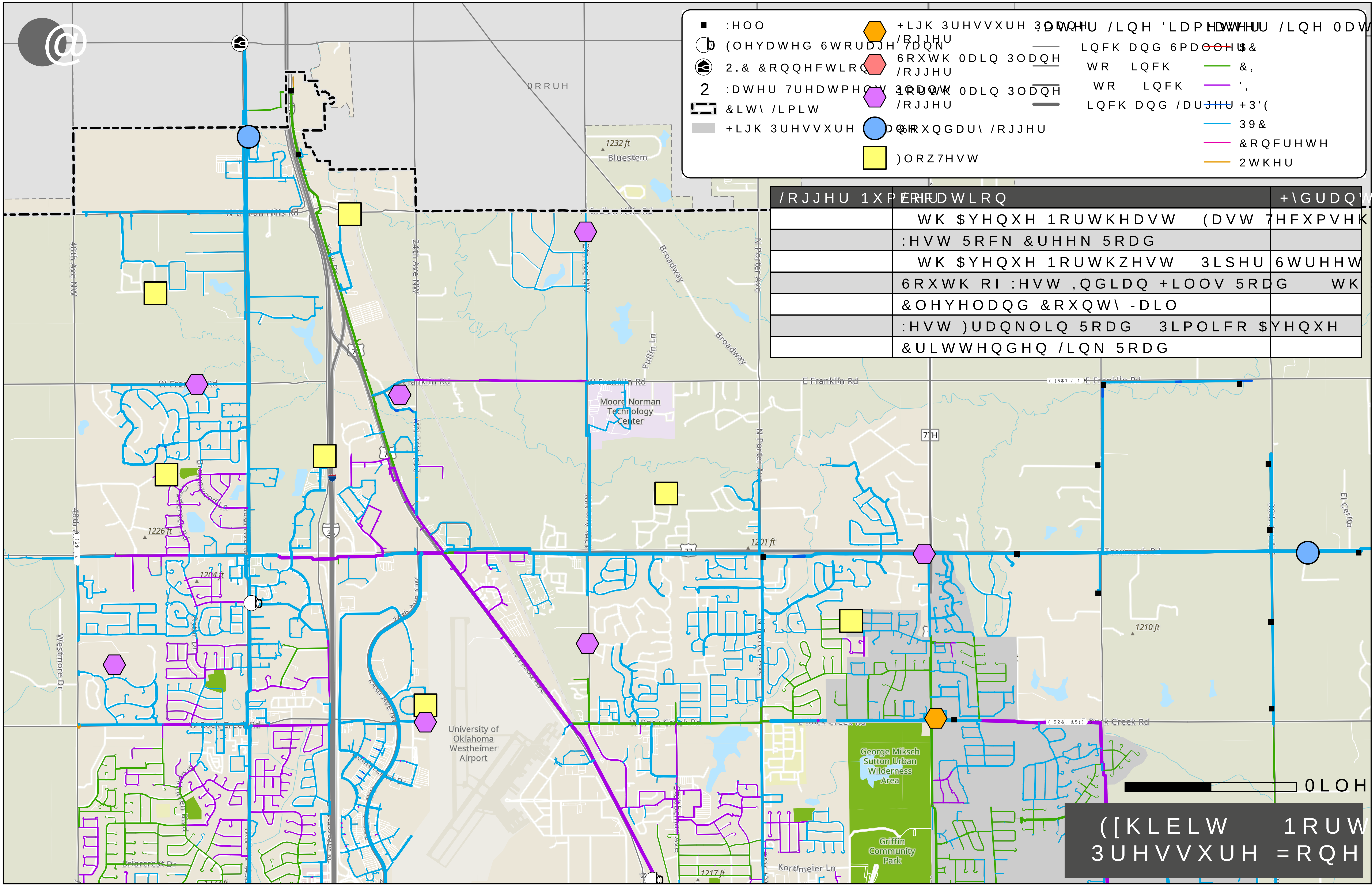

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W Franklin Rd
E Franklin Rd
E Rock Creek Rd
W Rock Creek Rd
Rock Creek Rd
Tecumseh Rd
Broadway
N Porter Ave
Pullin Ln
48th Ave NW
24th Ave NW
12th Ave NW
36th Ave NW
Westmore Dr
Briarcrest Dr
Kortimeler Ln
Stubbeman Ave
N Flood Ave
El Certo
Moore Norman Technology Center
University of Oklahoma Westheimer Airport
George Miksch Sutton Urban Wilderness Area
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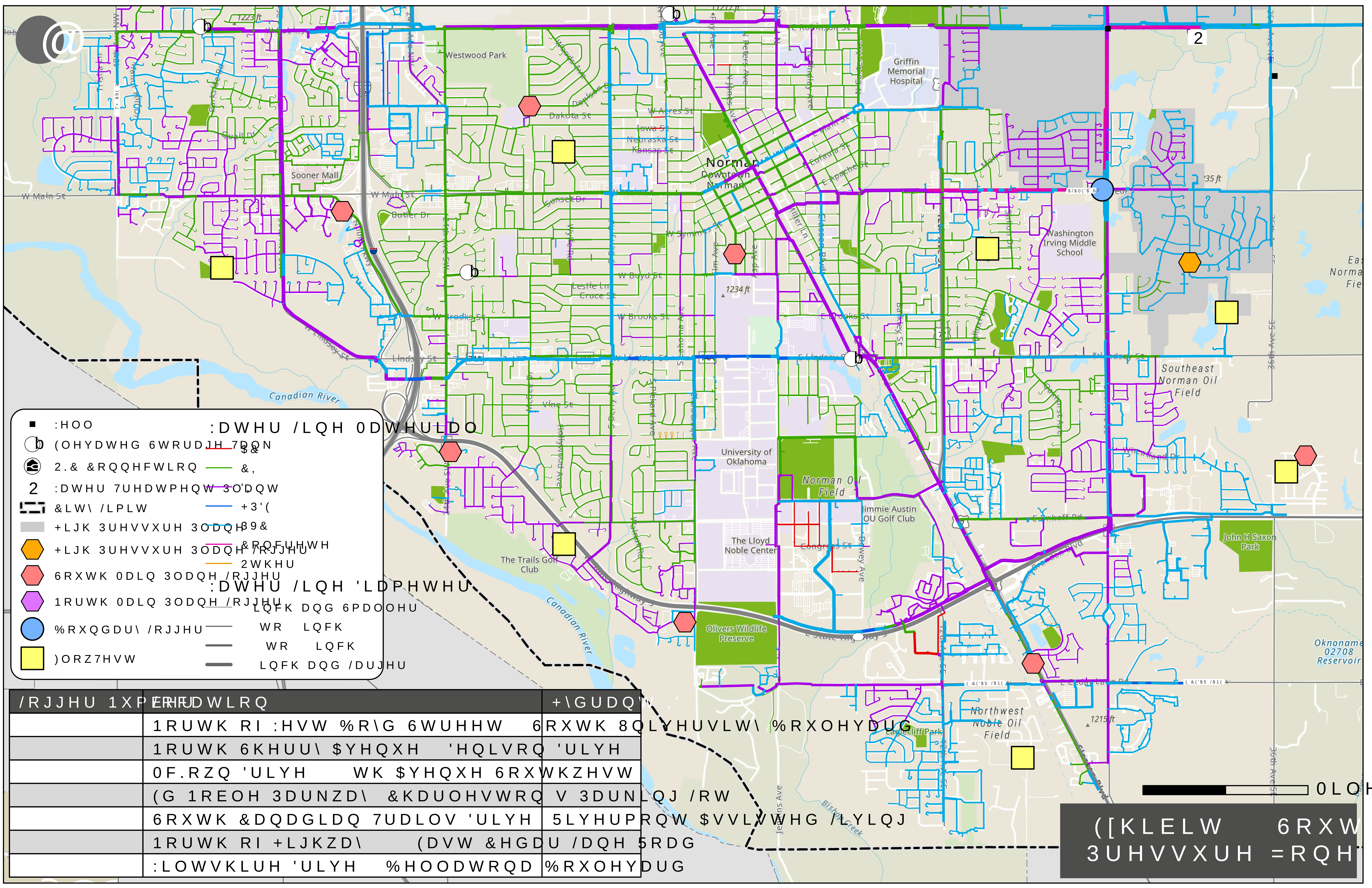
1204 ft
1201 ft
1210 ft
1217 ft



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	0F.RZQ 'ULYH	WK $YHQXH 6RXWKZHVW
	(G 1REOH 3DUNZD\	&KDUOHVWRQ V 3DUNLQJ /RW
	6RXWK &DQDGLDQ 7UDLOV 'ULYH	5LYHUPRQW $VVLVWHG /LYLQJ
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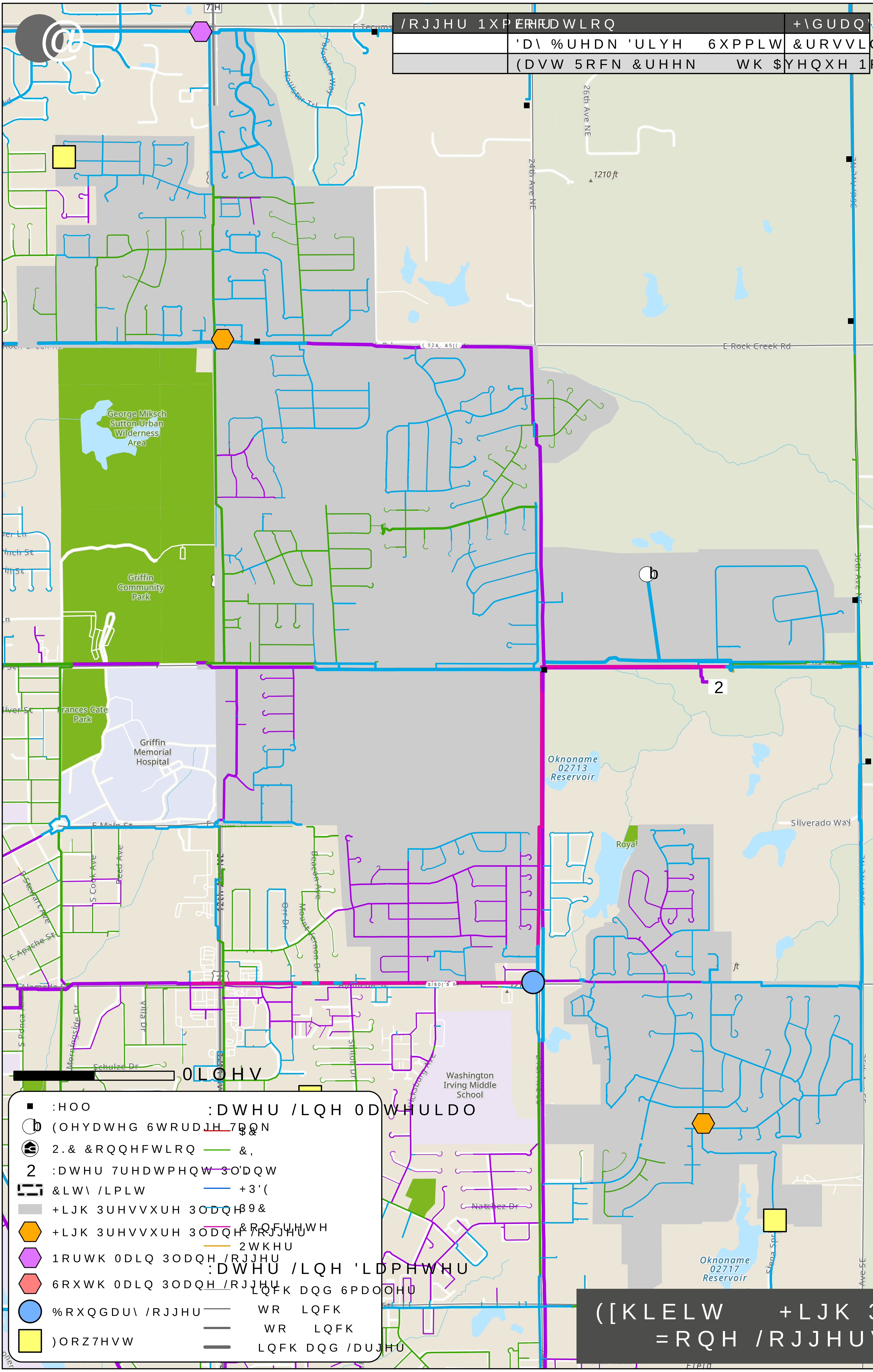

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E Tecumseh
Palomino Way
Hollister Trl
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26th Ave NE
1210 ft
E Rock Creek Rd
George Miksch Sutton Urban Wilderness Area
Griffin Community Park
Frances Cate Park
Griffin Memorial Hospital
Oknoname 02713 Reservoir
Silverado Way
Royal
E Main St
S Cook Ave
Reed Ave
Beacon Ave
Orr Dr
Mount Vernon Dr
E Apache St
Stewart Ave
Morningside Dr
Villa Dr
Schulze Dr
Washington Irving Middle School
Natchez Dr
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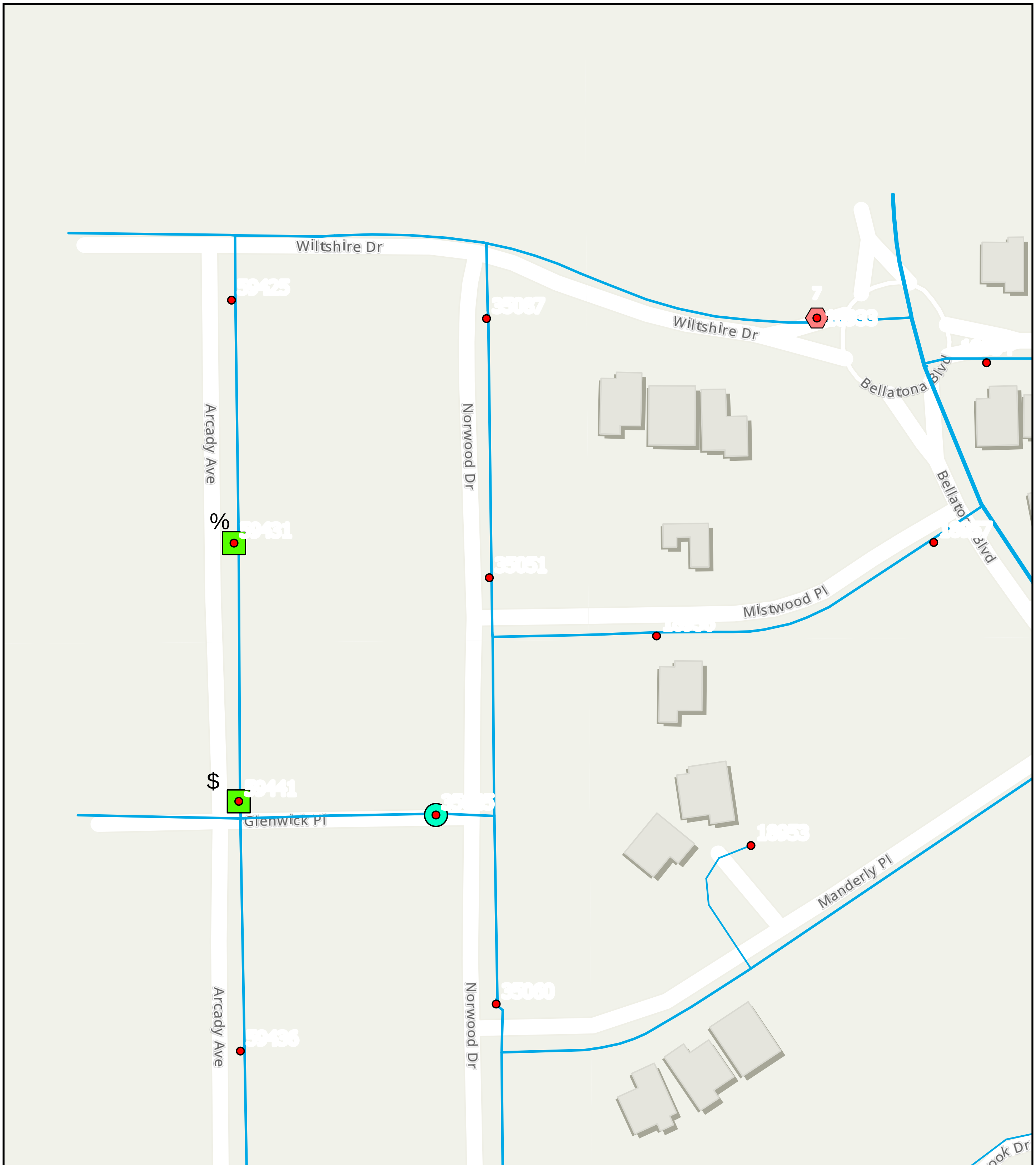

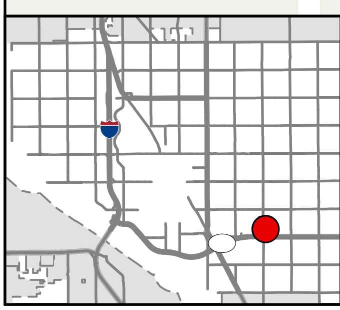

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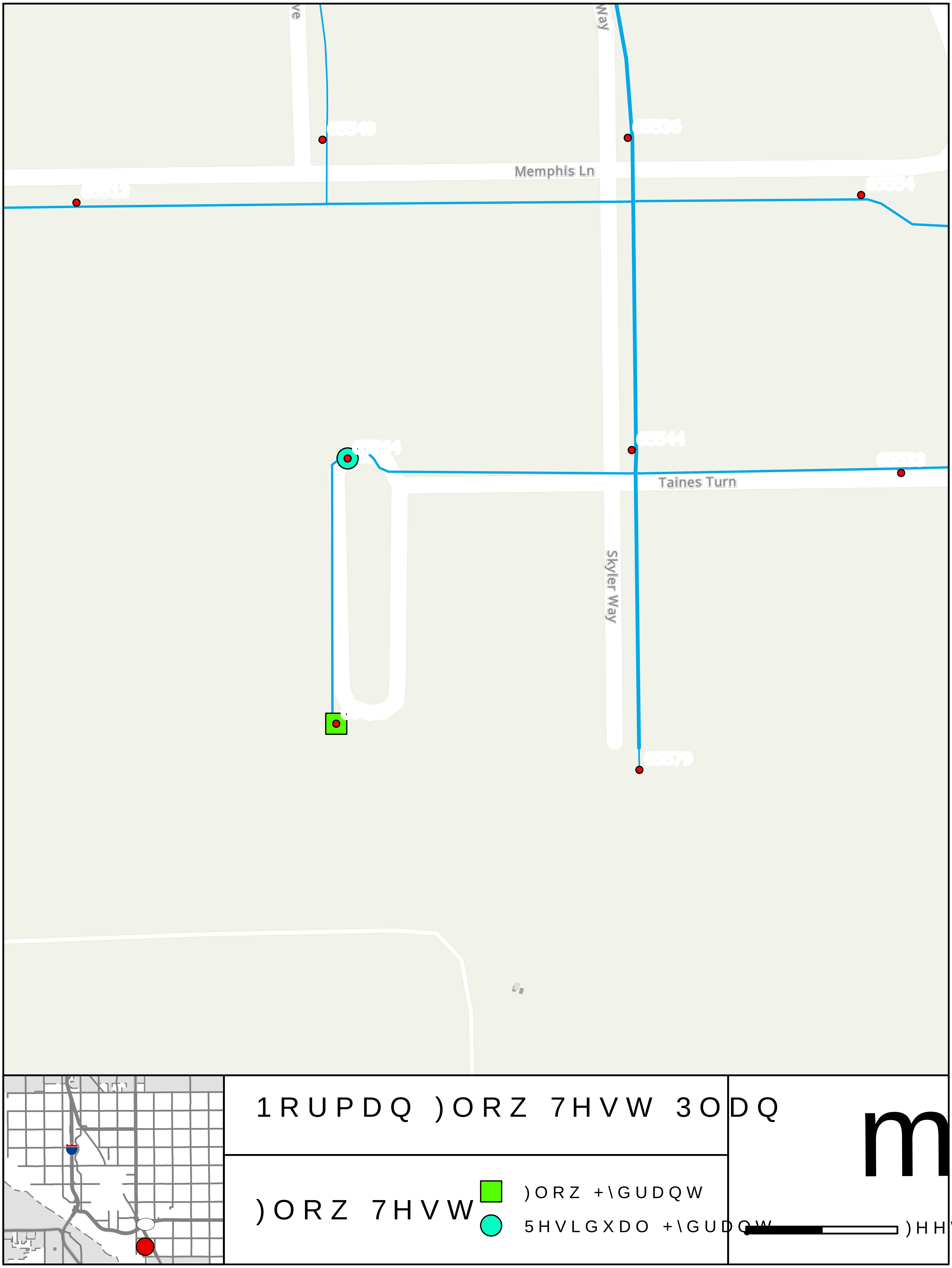

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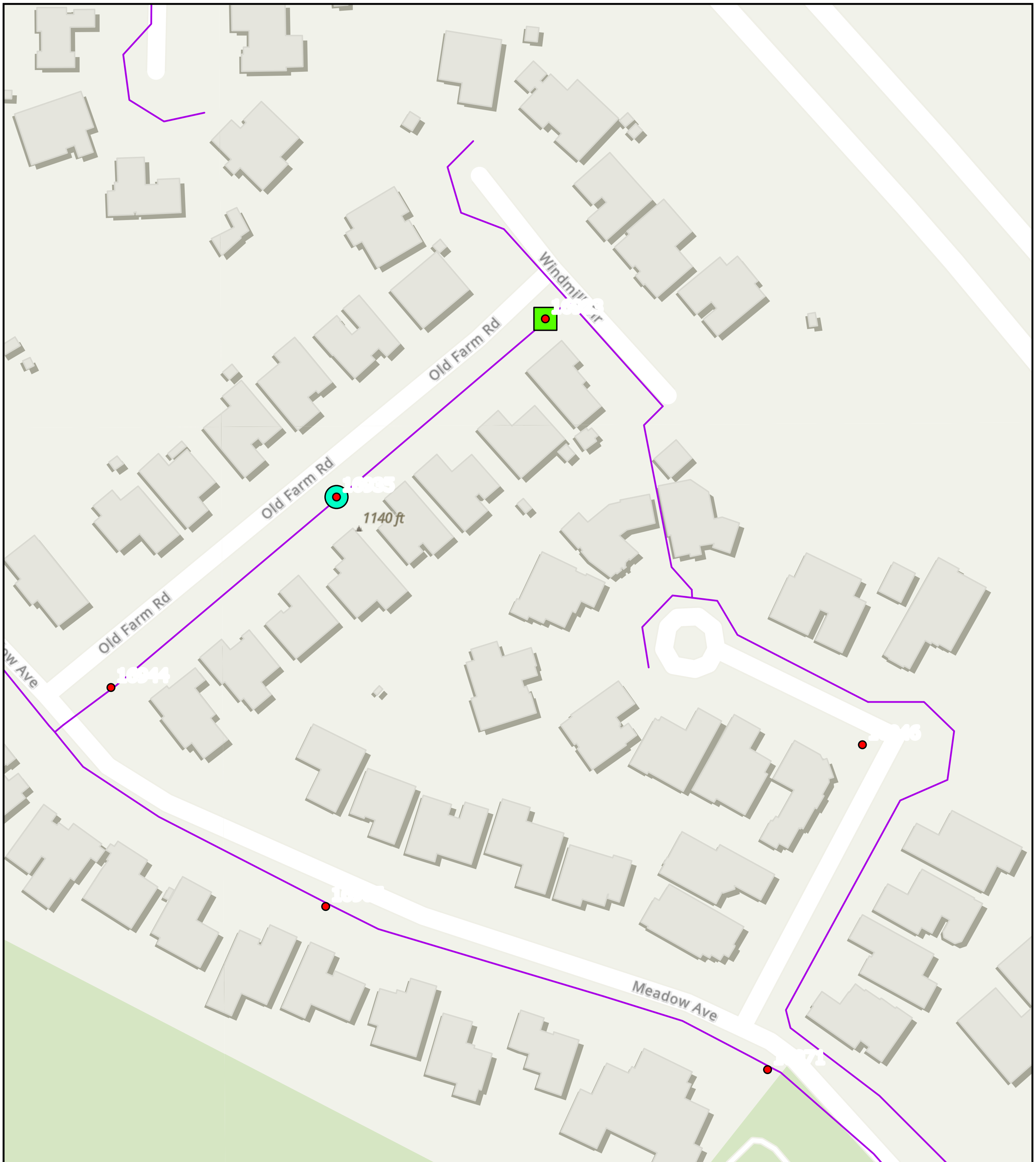
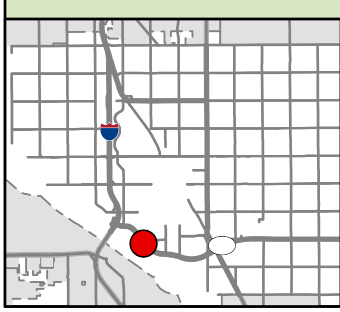
5HVLGXDO +\GUDQW

)HHW





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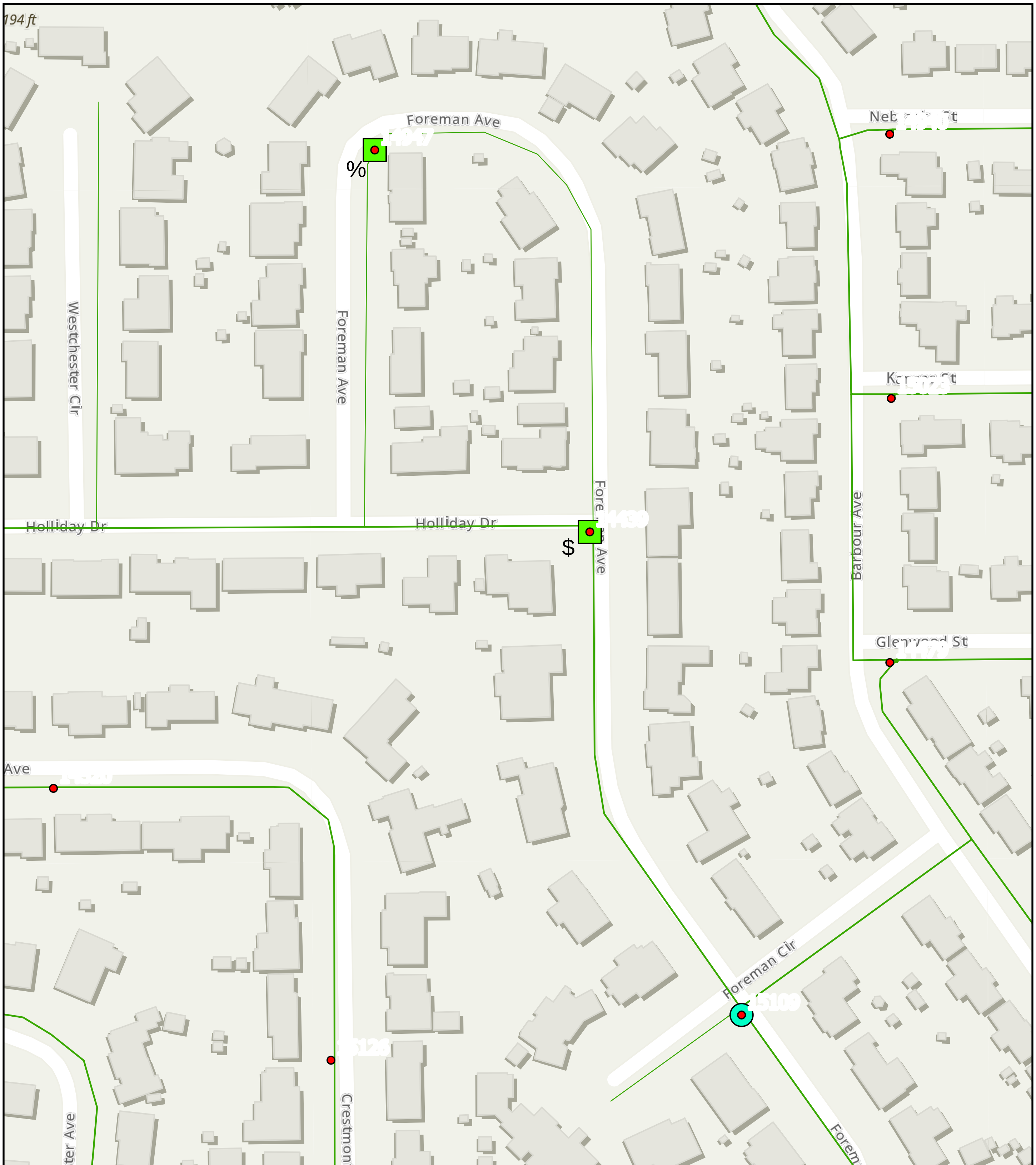

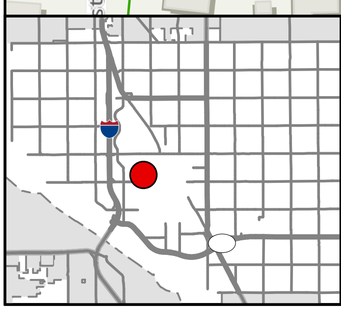

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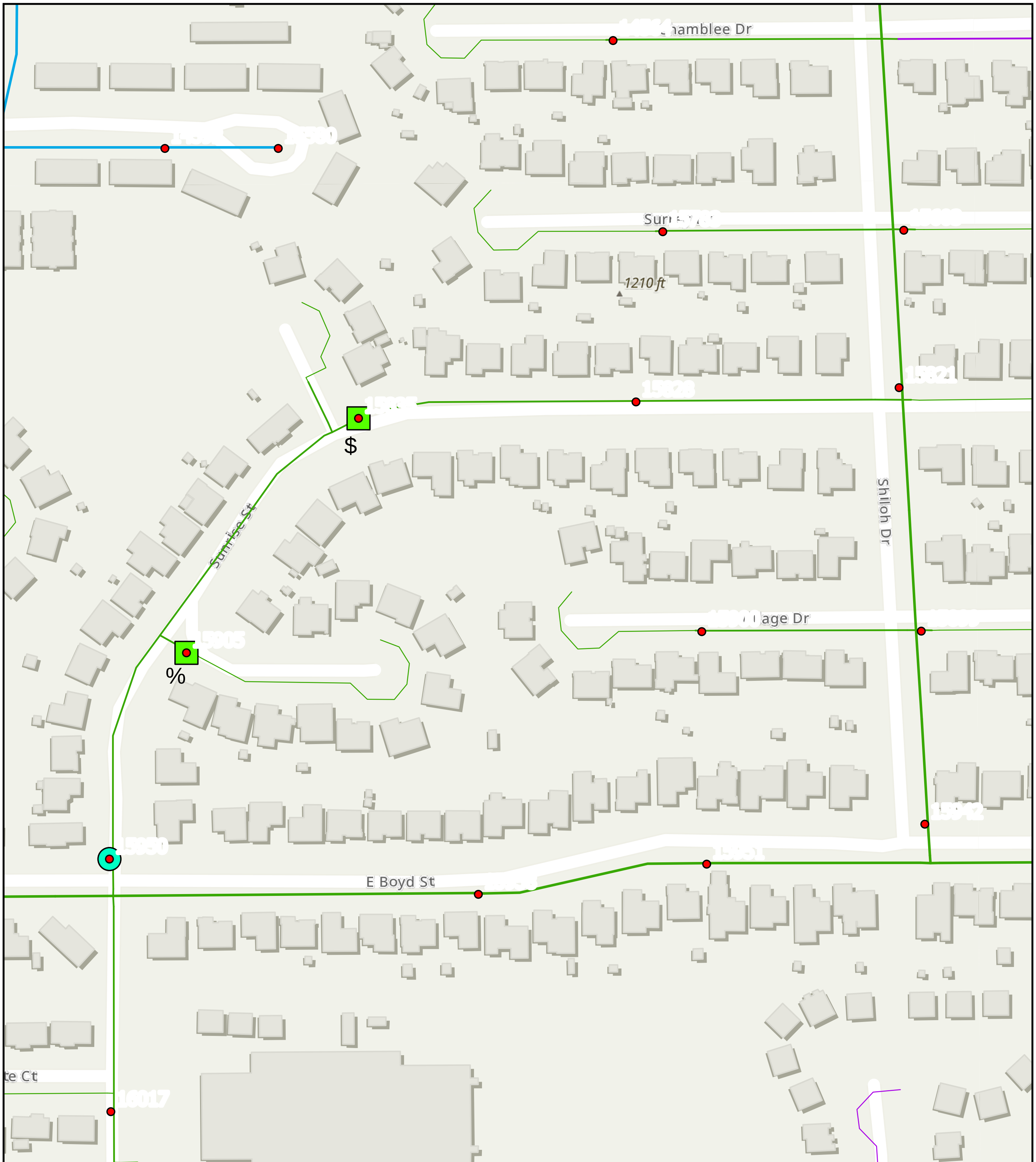

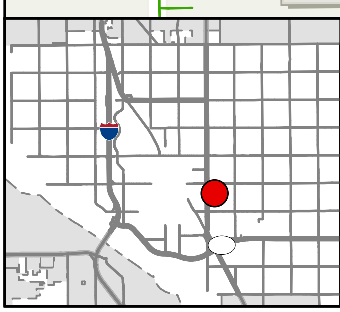

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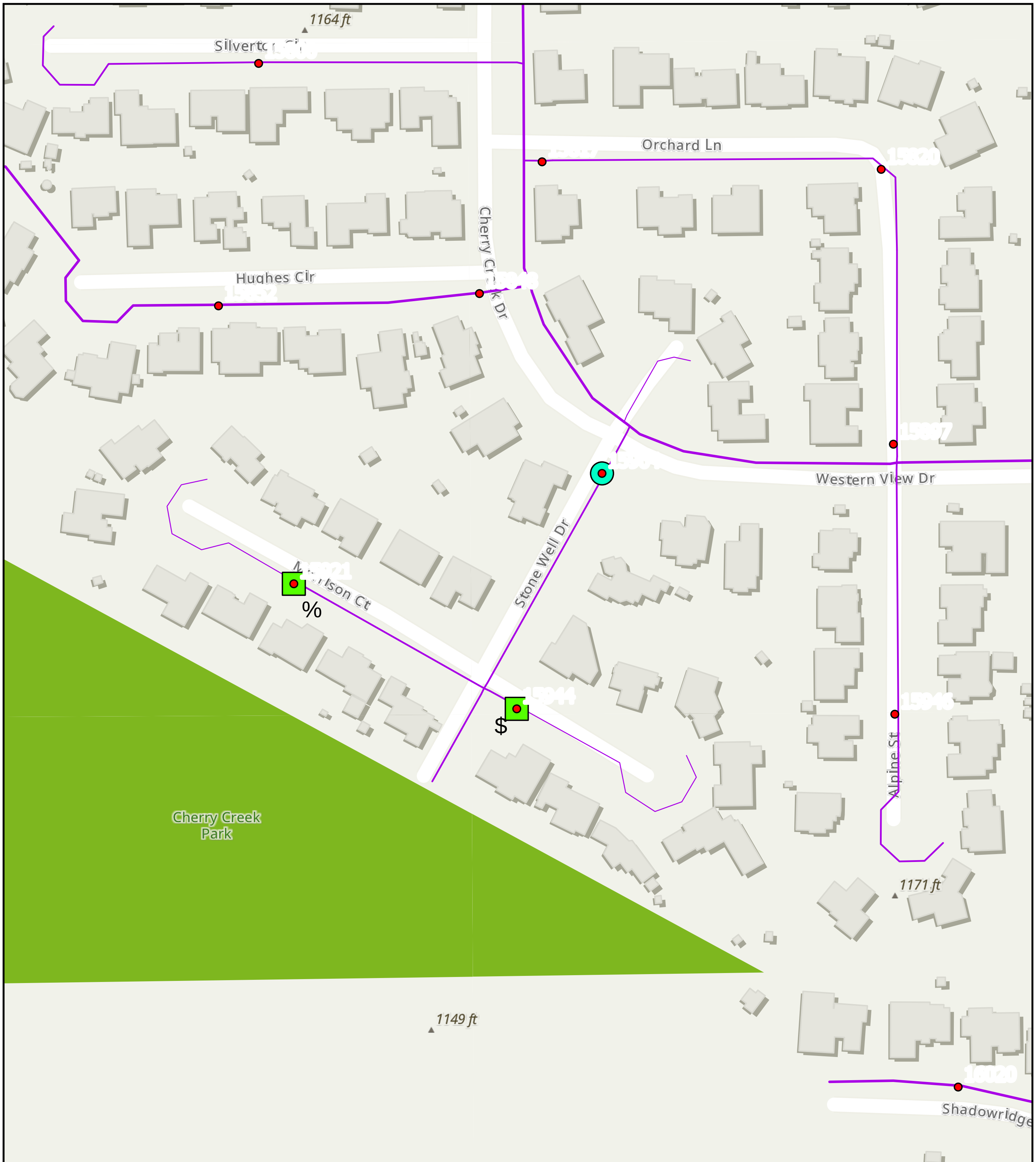
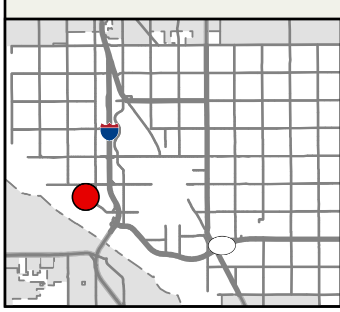
)ORZ 7HVW

)ORZ +\GUDQW

5HVLGXDO +\GUDQW

)HHW





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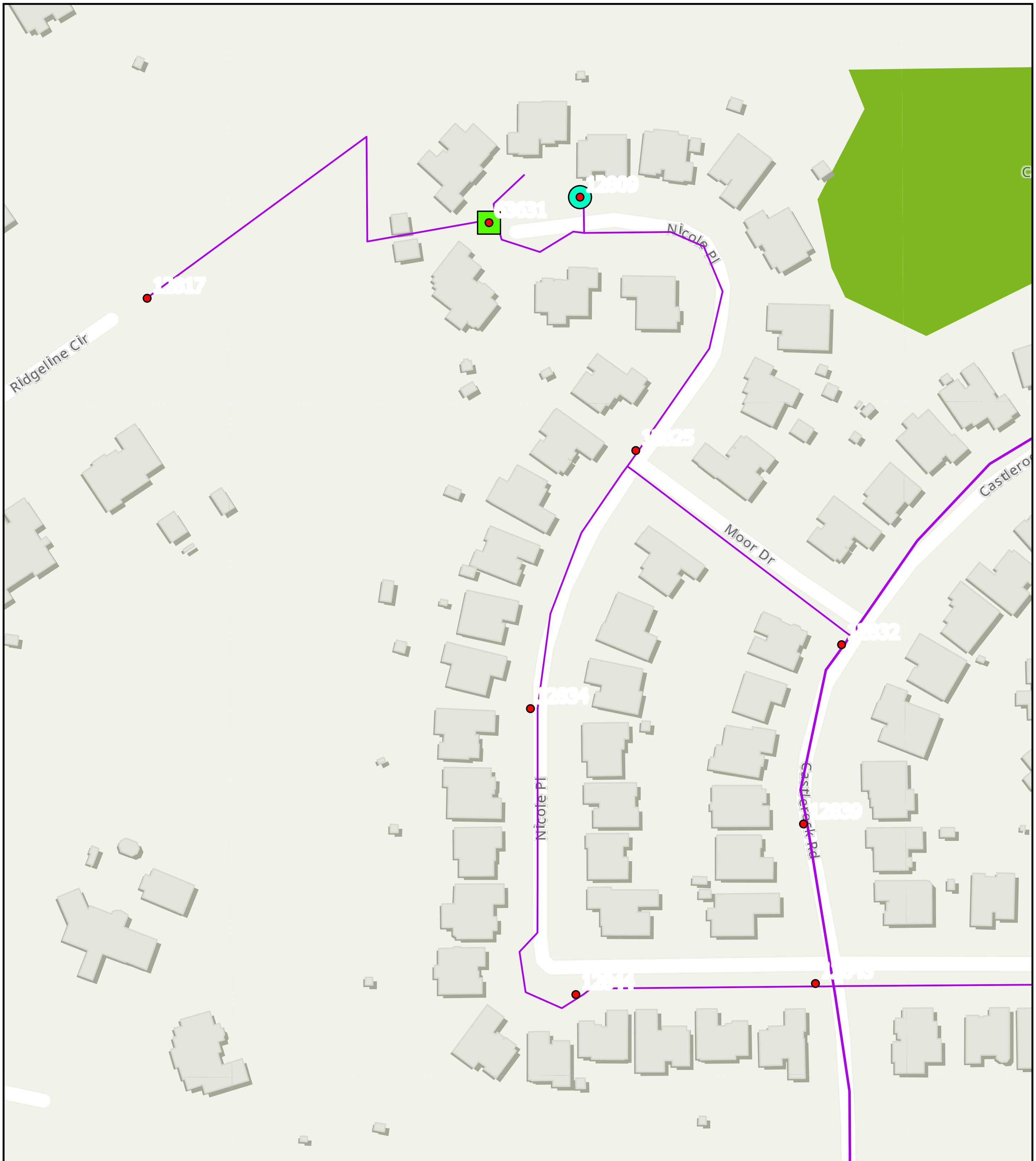

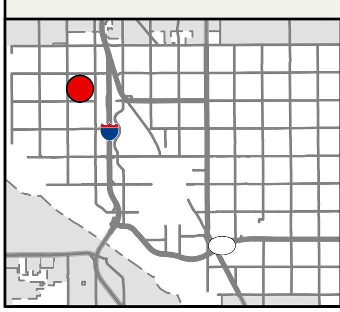

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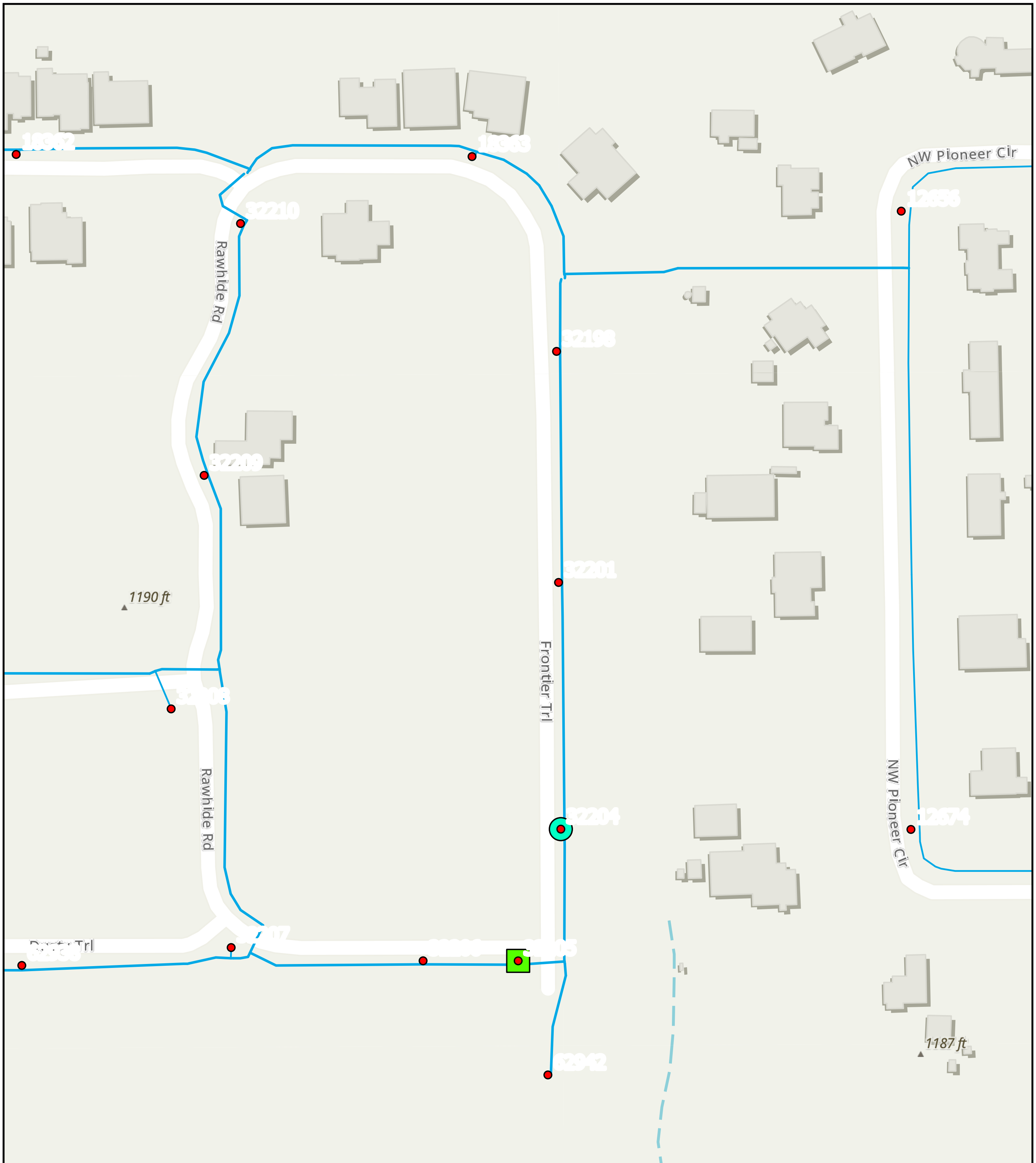
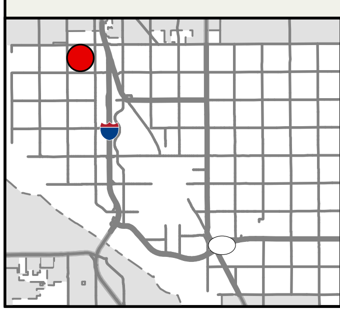
m

)HHW





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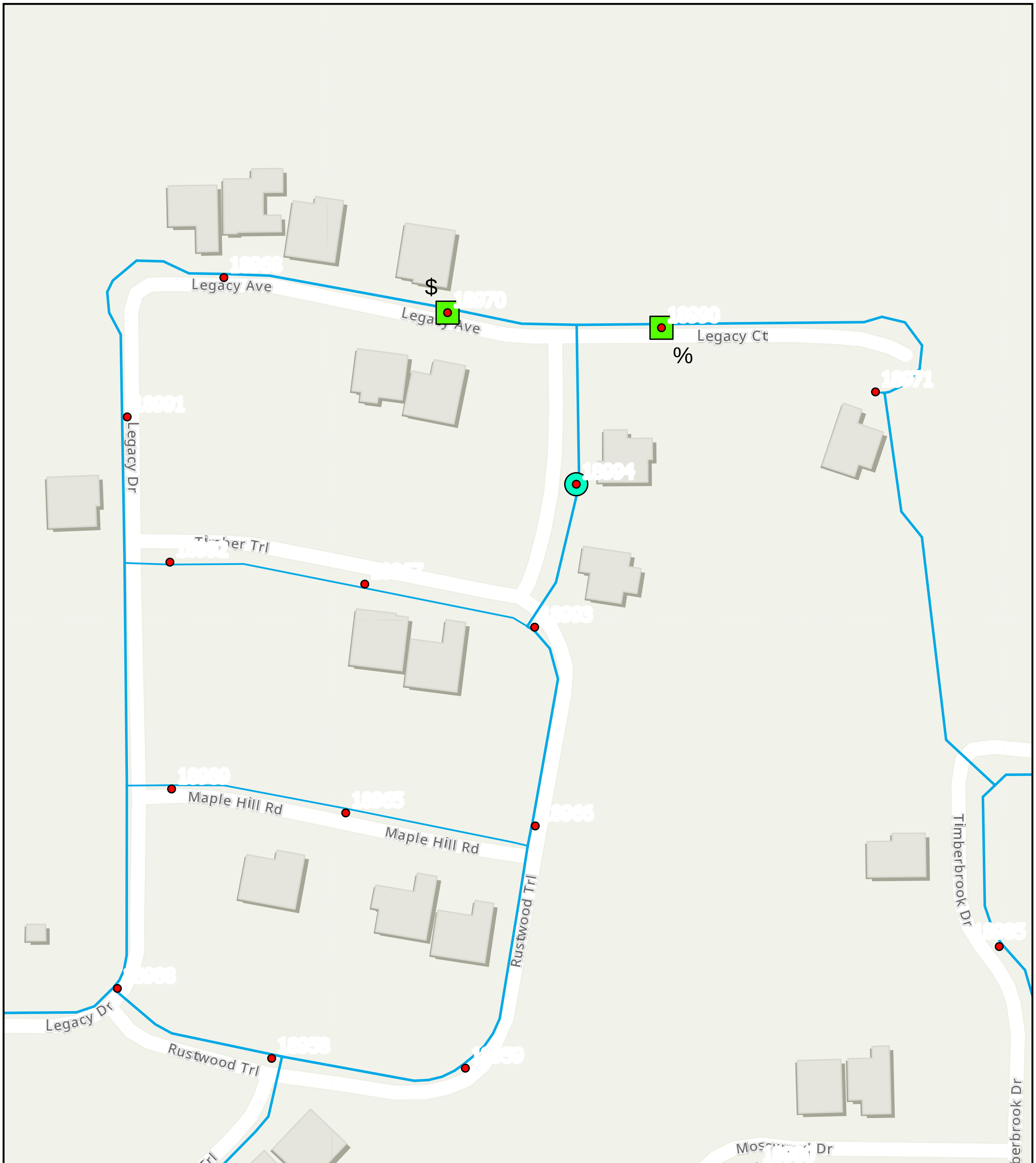

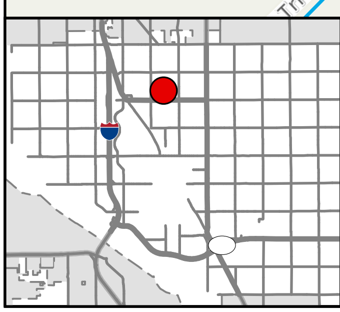

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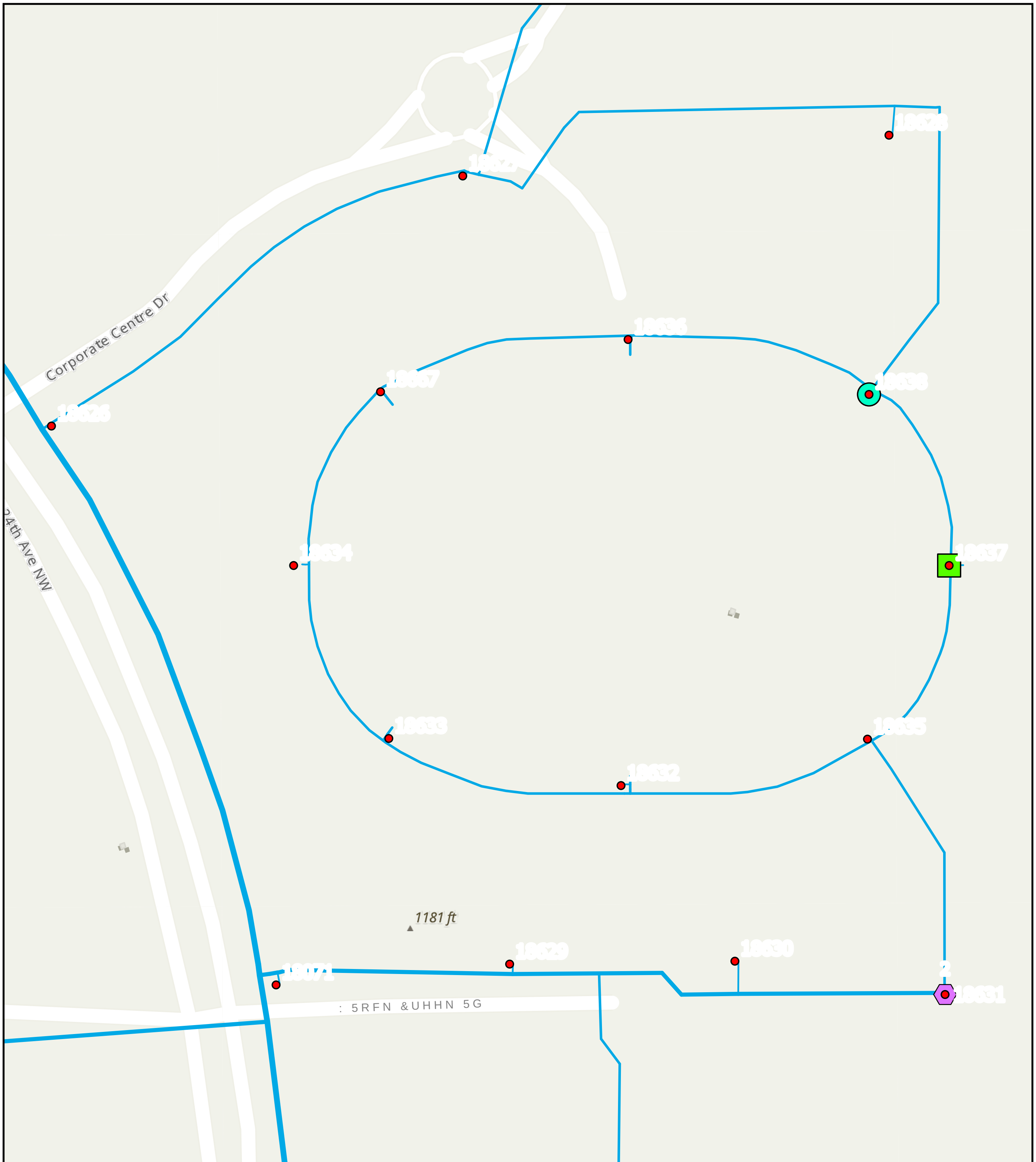

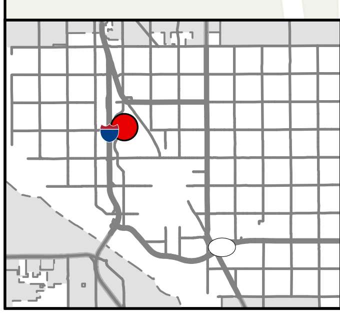

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1RUWK 0DLQ 3UHVVXUH =RQH /RJJHU

m

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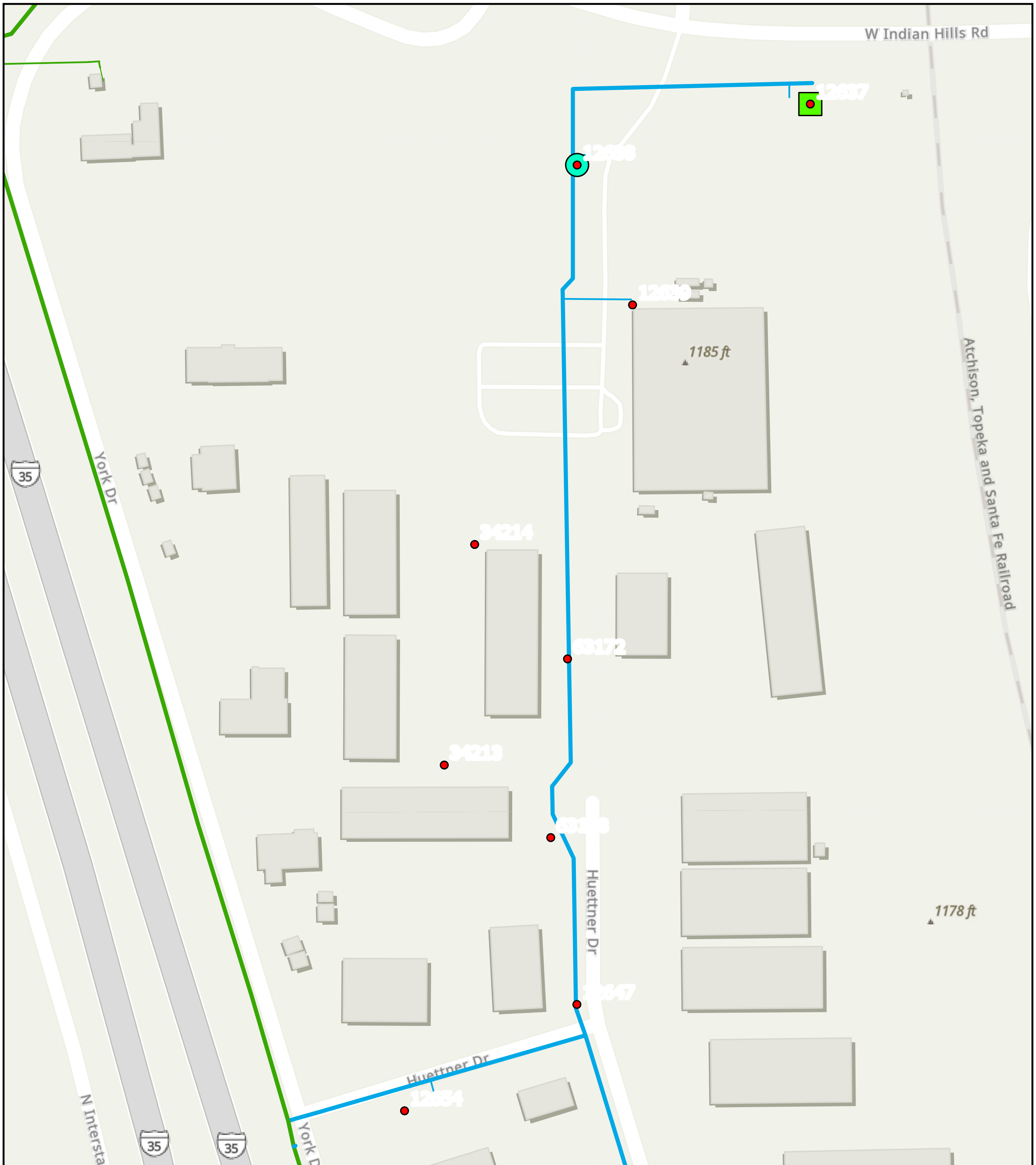

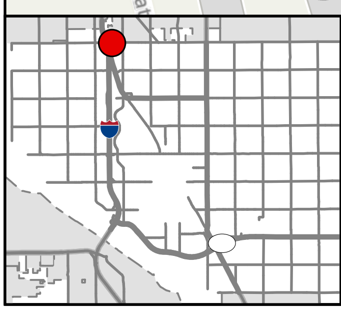

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)ORZ +\GUDQW

5HVLGXDO +\GUDQW

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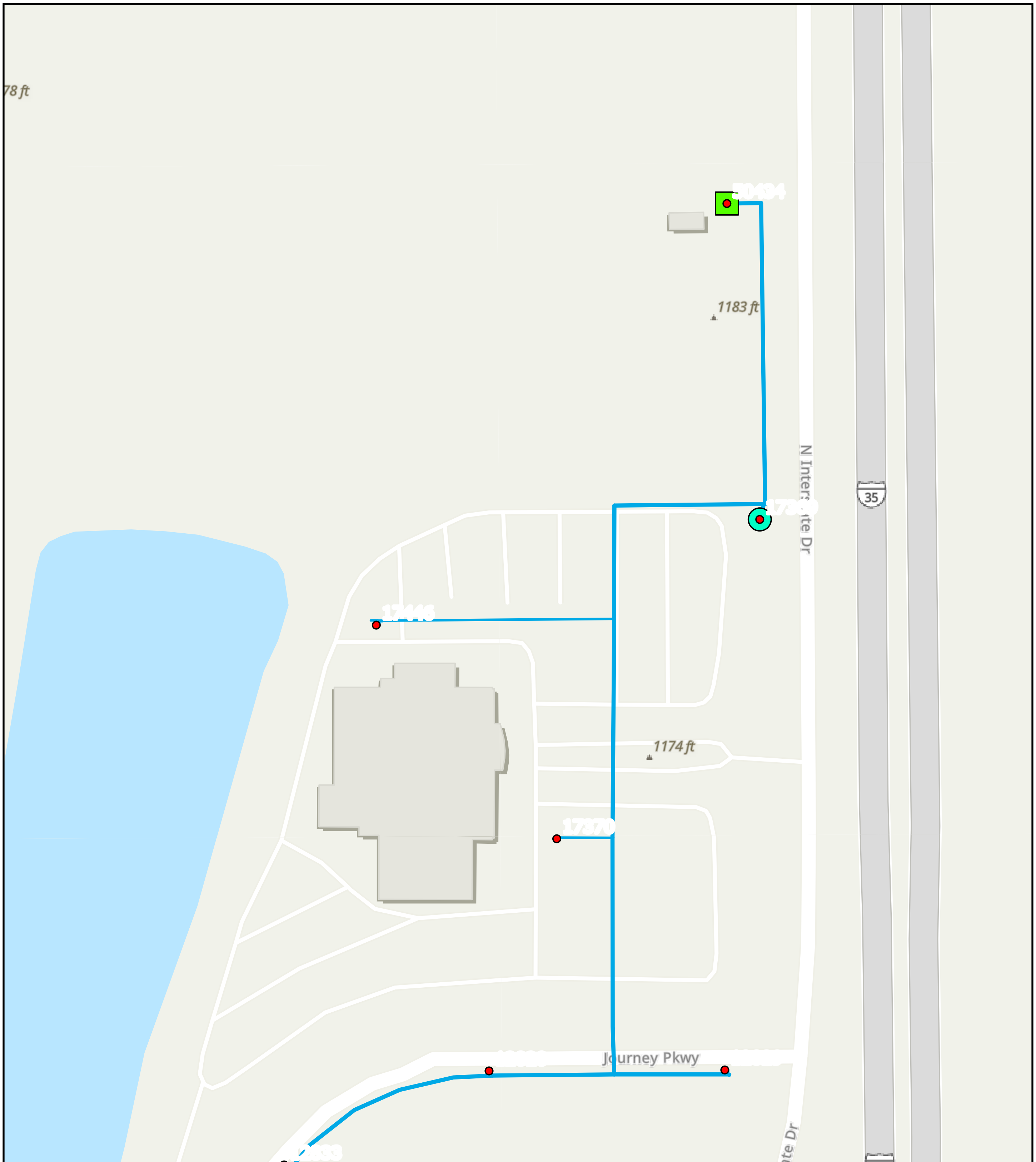
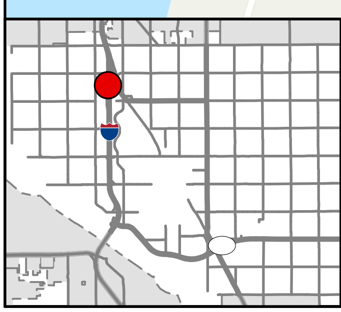
)HHW





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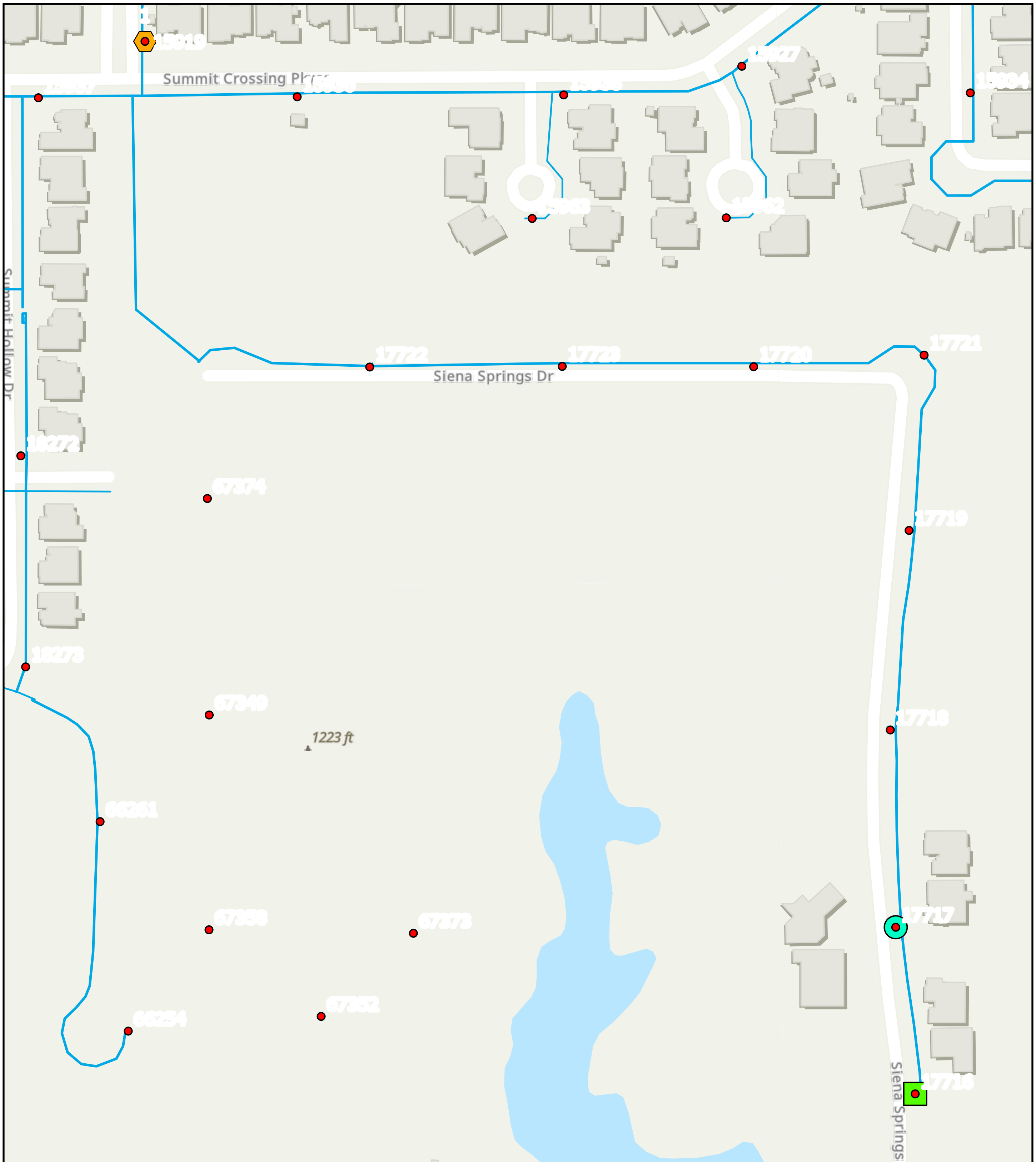
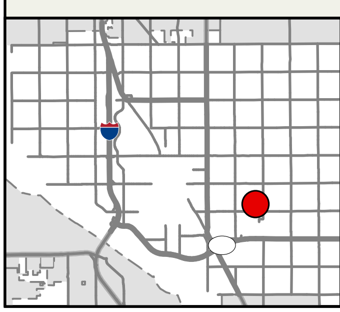
)HHW





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+LJK =RQH 3UHVVXUH /RJJHU

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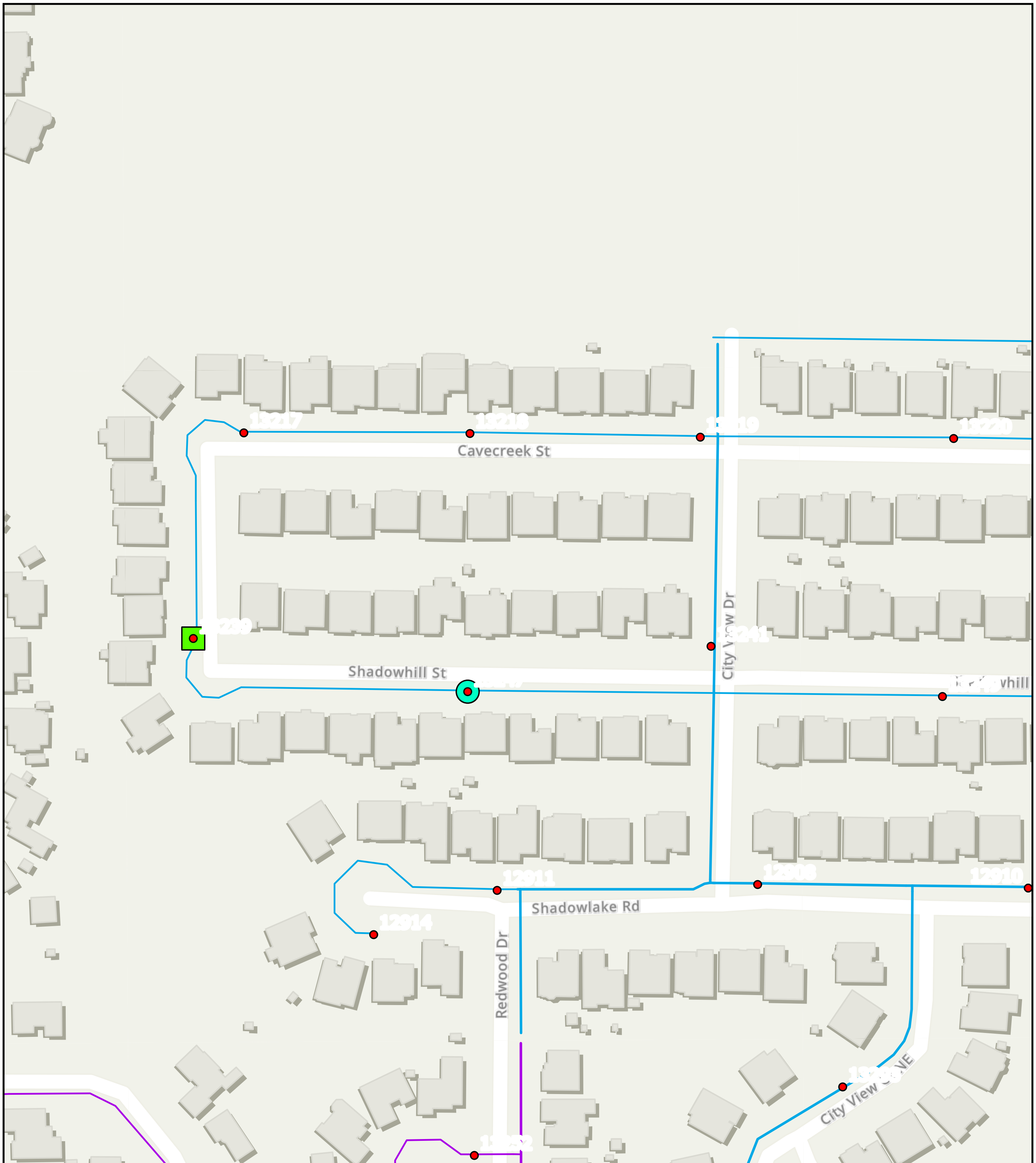

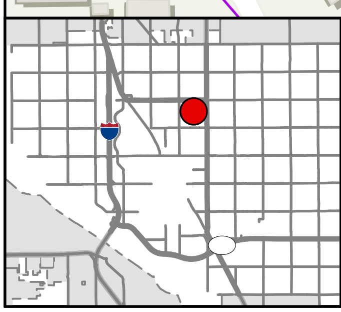

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)ORZ 7HVW

)ORZ +\GUDQW

5HVLGXDO +\GUDQW

)HHW

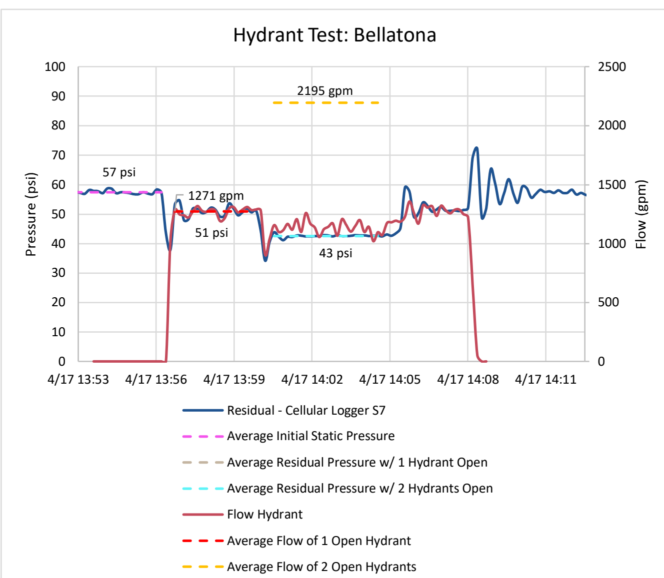
m

Flow Testing Field Data Sheet

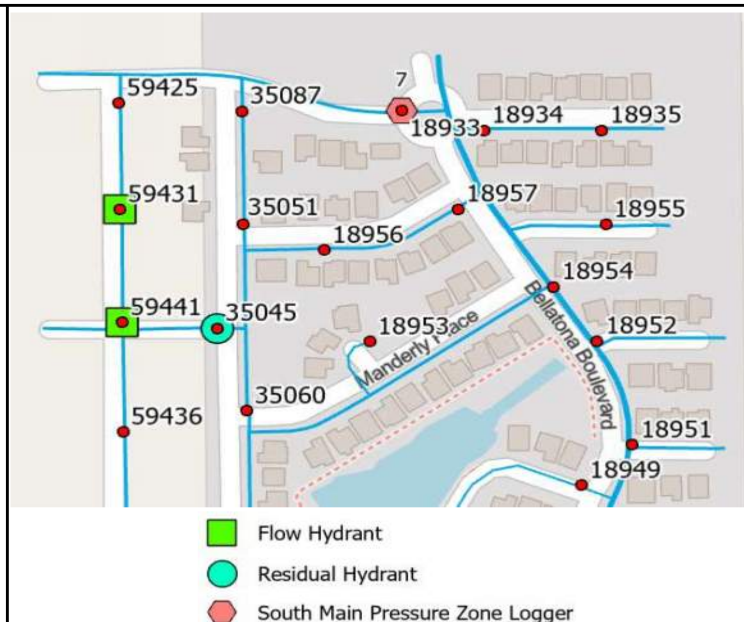
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**1**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	S.Sikes & M. Nguyen
Location/Address:	**GLENWICK PLACE & ARACADY AVENUE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 59441	**35045**	**70**	**2.5**	**13:57**	**58 psi**	**66**	**14:07**
Hydrant 2 (if needed) No. 59434	**35045**	**70**	**2.5**	**14:00**	**1060 gpm**	**65 psi**	**14:05**

Chart:



Vicinity Map:

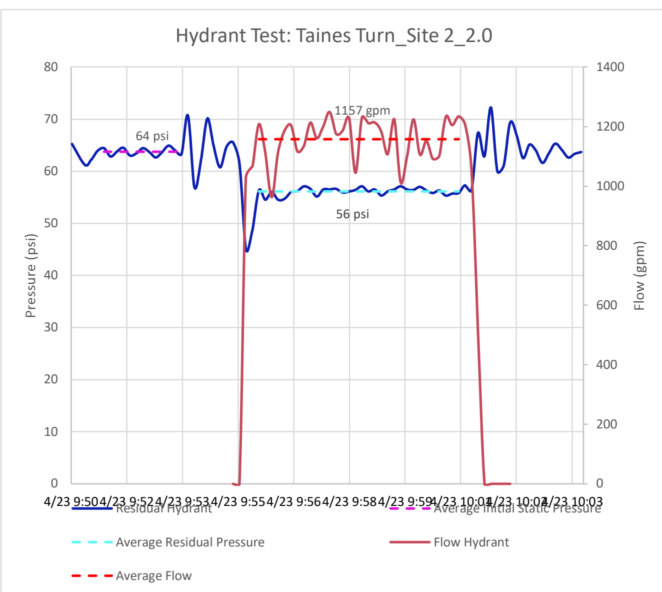


Flow Testing Field Data Sheet

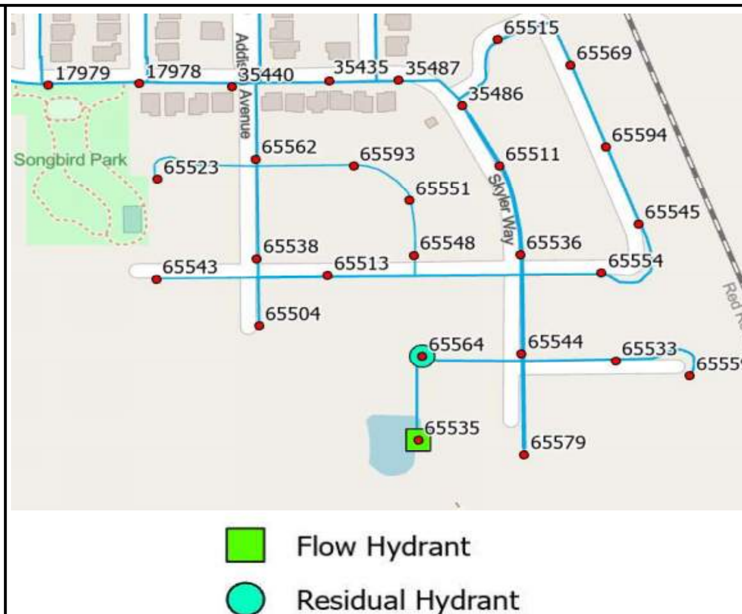
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**2**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	S.Sikes & M. Nguyen
Location/Address:	**SKYLER WAY & TAINES TURN**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 65535	**65564**	**68**	**2.5**	**14:38**	**54 psi**	**67**	**14:43**
Hydrant 2 (if needed) No.							

Chart:



Vicinity Map:

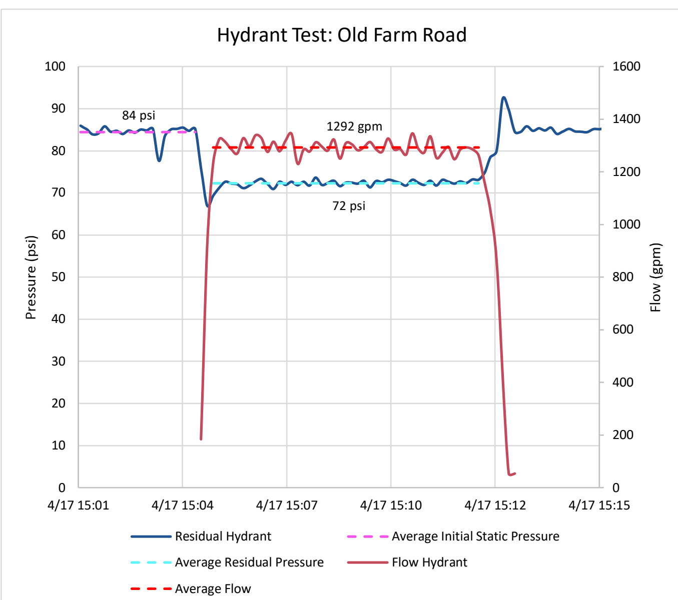


Flow Testing Field Data Sheet

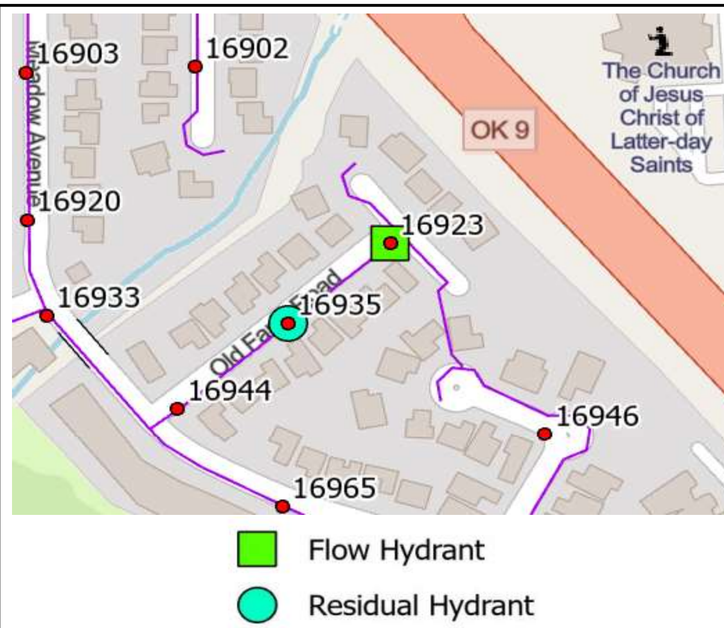
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**3**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**OLD FARM RD & WINDMILL CIRCLE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 16923	**19635**	**85**		**15:05**	**60 psi**	**72**	**15:11**
Hydrant 2 (if needed) No. ______							

Chart:



Vicinity Map:

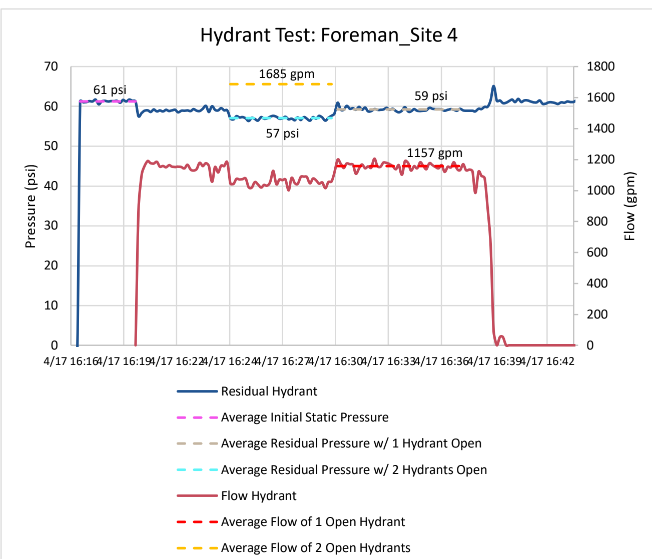


Flow Testing Field Data Sheet

Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**4**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**FOREMAN AVENUE & HOLLIDAY DRIVE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 14439	**15109**	**61**		**16:20**	**51 psi w A open only** **40 psi w A&B open**	**58**	**16:37**
Hydrant 2 (if needed) No. 14947	**15109**	**61**		**16:23**	**630 gpm**	**56**	**16:29**

Chart:



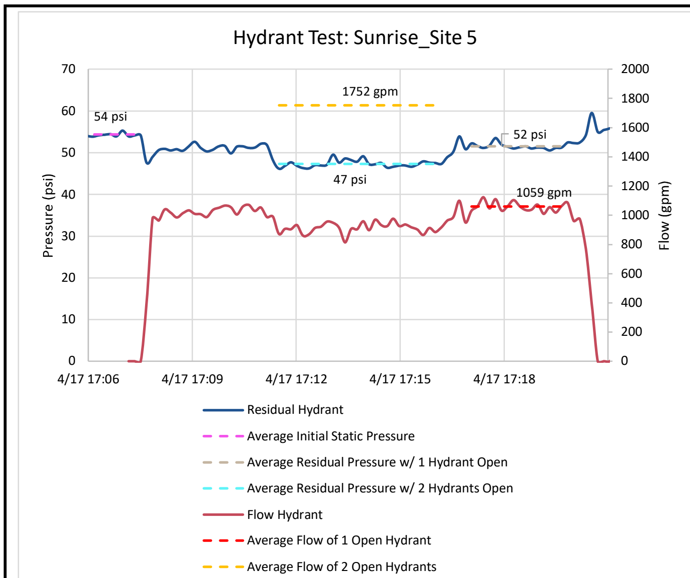
Vicinity Map:

Flow Testing Field Data Sheet

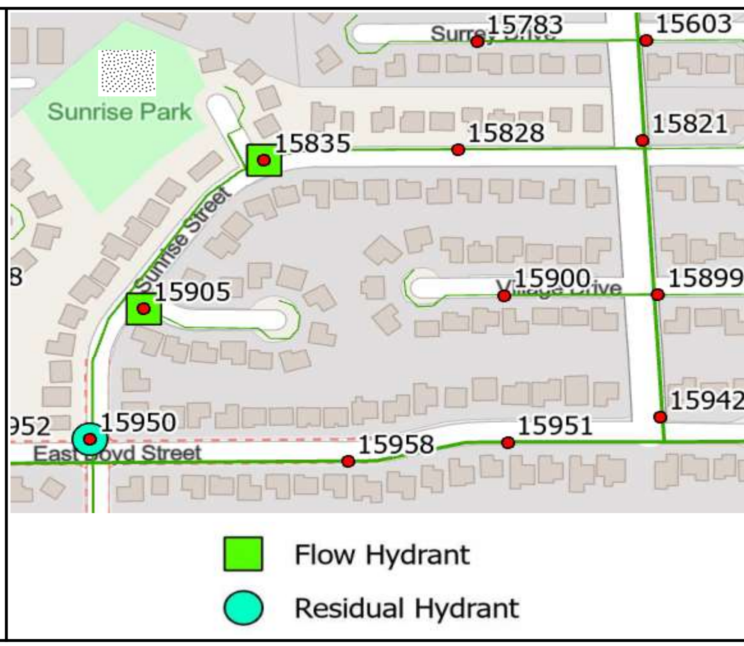
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**5**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**SUNRISE STREET& SKYLINE DRIVE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 15835	**15950**	**54**		**15:12**	**38 psi w/only B open 27 psi w/ A&B open**	**52**	**15:14**
Hydrant 2 (if needed) No. 15905	**15950**	**54**		**15:09**	**840 gpm**	**47**	**15:19**

Chart:



Vicinity Map:

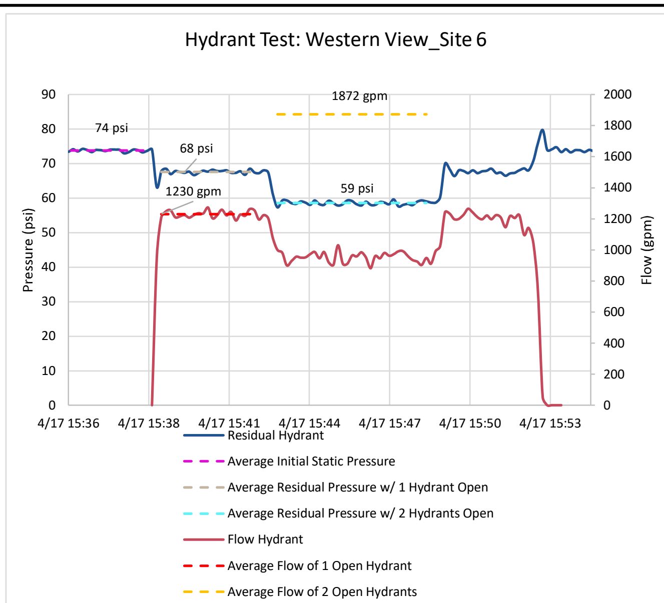


Flow Testing Field Data Sheet

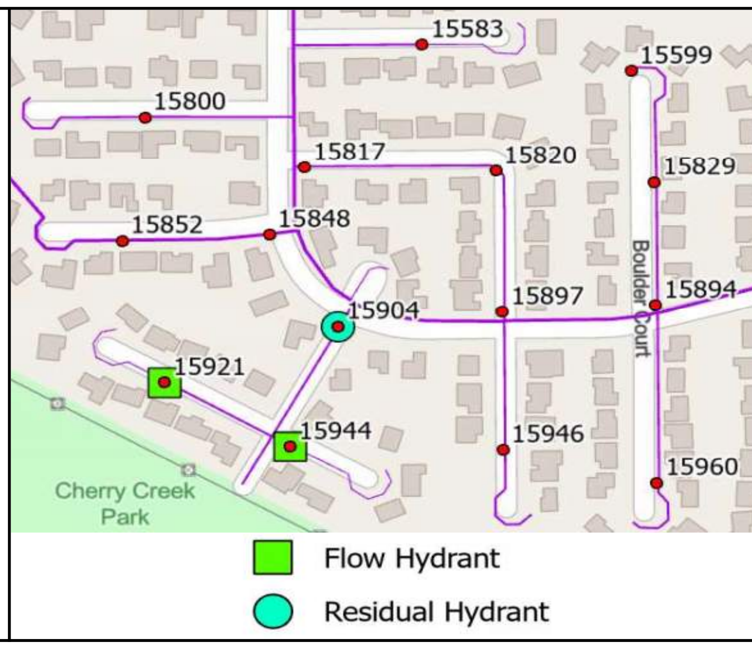
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**6**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**WESTERN VIEW & STONEWELL**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 15944	**15904**	**74**	**2.5**	**15:39**	**53 psi**	**67**	**15:51**
Hydrant 2 (if needed) No. 15921	**15904**	**74**	**2.5**	**15:43**	**920 gpm**	**58**	**15:48**

Chart:



Vicinity Map:

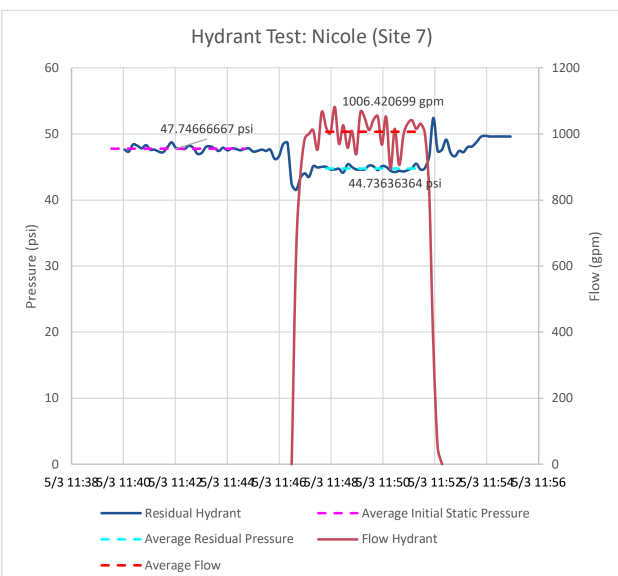


Flow Testing Field Data Sheet

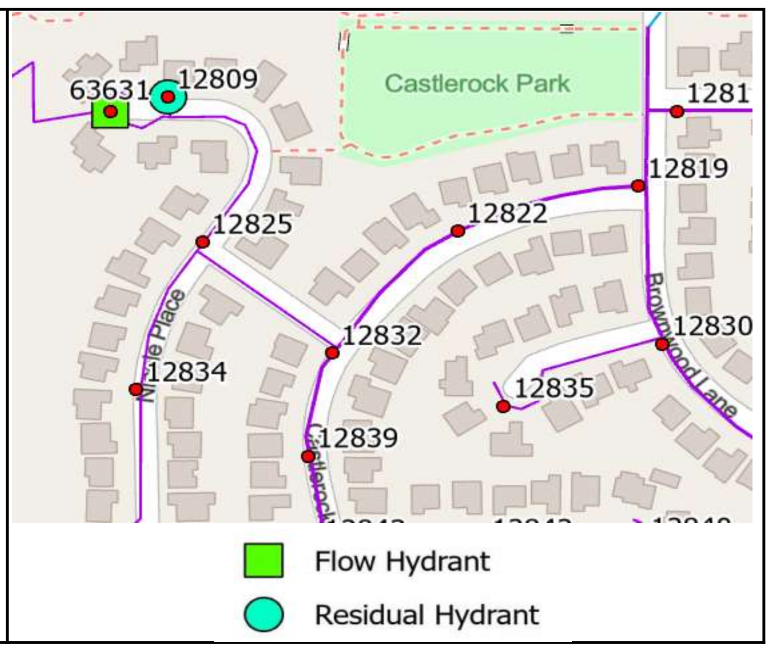
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**7**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**NORTH OF MOOR DRI VER & NICOLE PLACE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 63631	**12825**	**48**		**11:46**	**39 psi**	**45**	**11:51**
Hydrant 2 (if needed) No.							

Chart:



Vicinity Map:



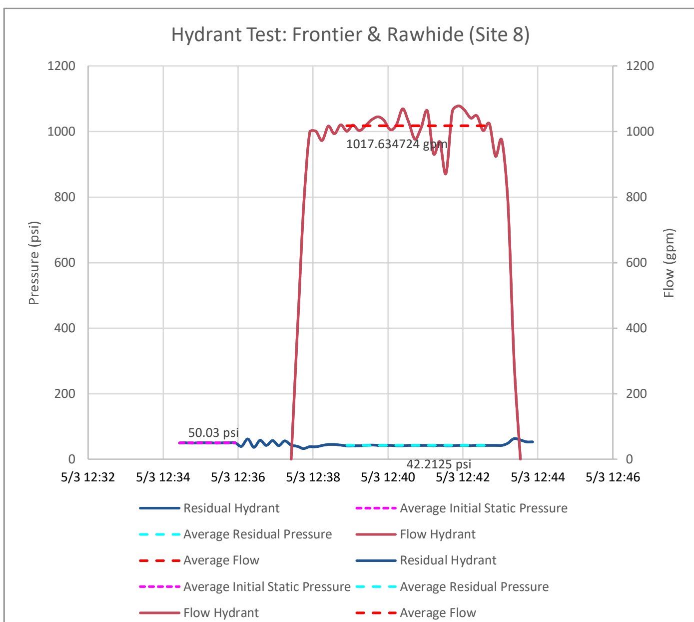
GARVER

Flow Testing Field Data Sheet

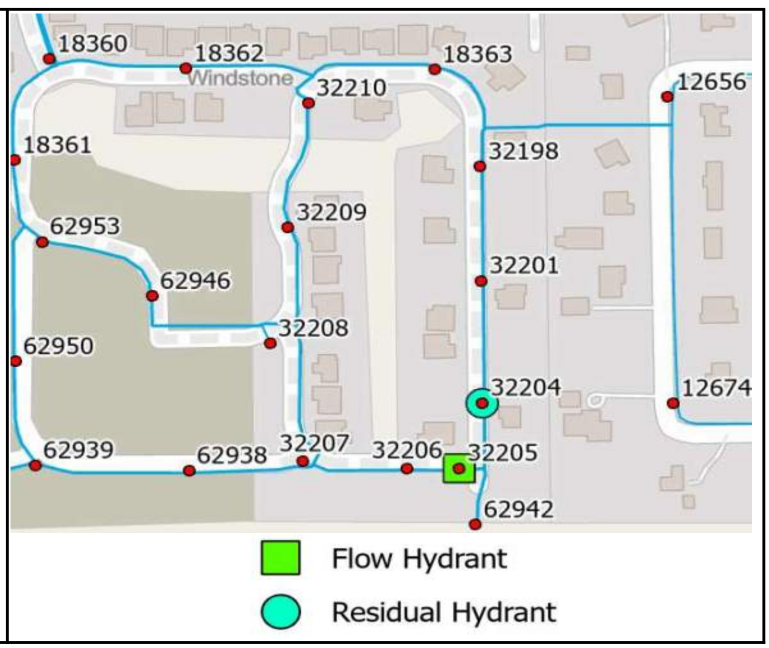
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**8**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**FRONTIER TRAIL**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 32205	**32204**	**51**		**12:39**	**36 psi**	**45**	**12:44**
Hydrant 2 (if needed) No. ____________							

Chart:



Vicinity Map:

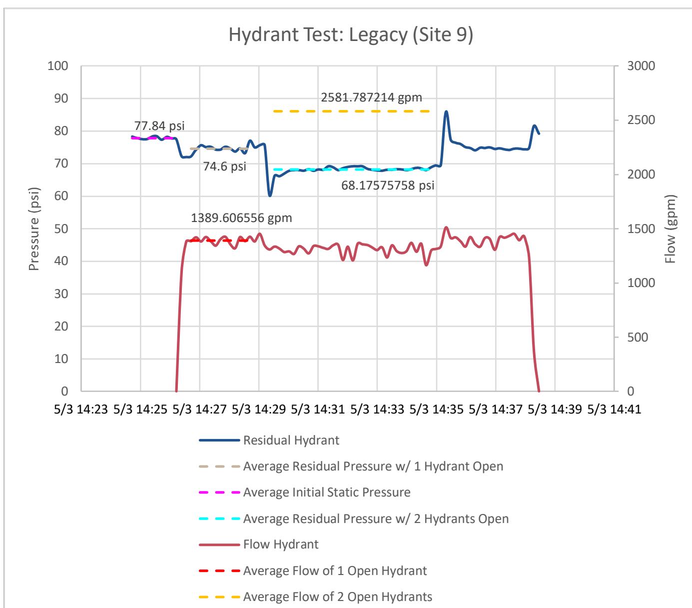


Flow Testing Field Data Sheet

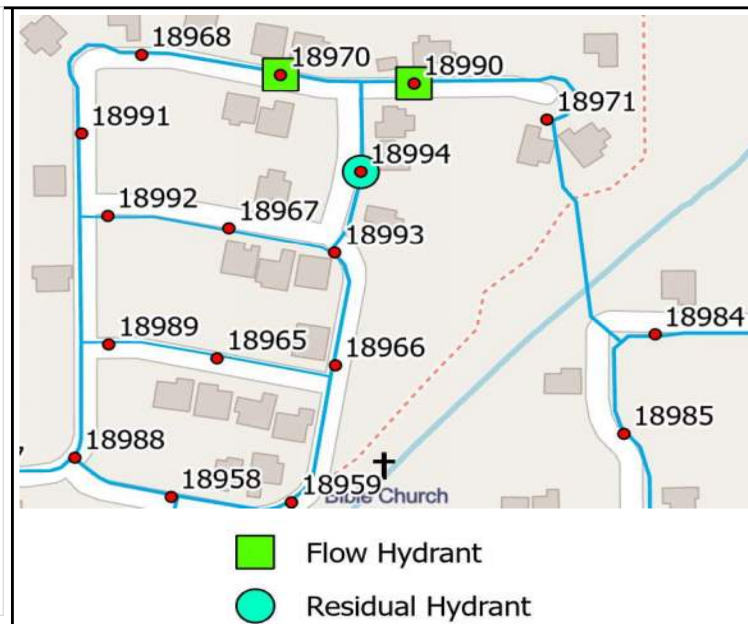
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**9**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**LEGACY CT**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 18970	**18994**	**78**		**2:26**	**62 psi**	**74**	**2:38**
Hydrant 2 (if needed) No. 18990	**18994**	**78**		**2:30**	**1275 GPM**	**67**	**2:35**

Chart:



Vicinity Map:



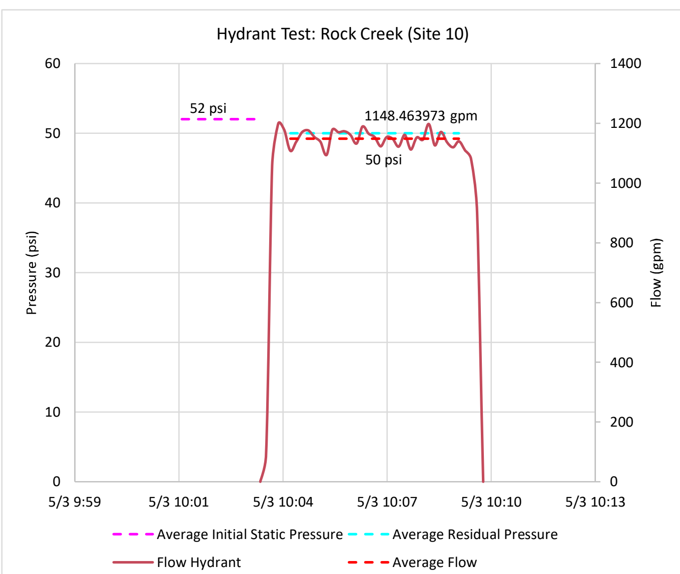
GARVER

Flow Testing Field Data Sheet

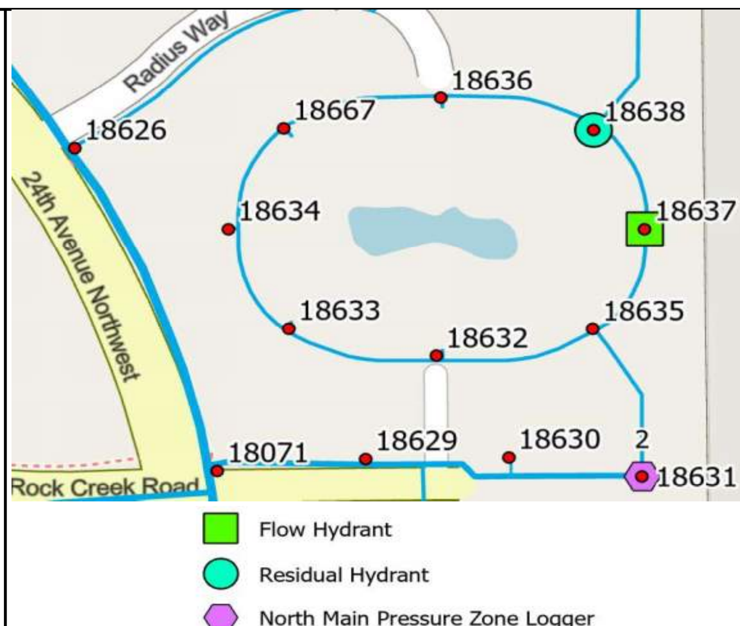
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**10**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**ROCK CREEK ROAD**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 18638	**18637**	**52**		**10:04**	**51 psi**	**50 psi**	**10:09**
Hydrant 2 (if needed) No.							

Chart:



Vicinity Map:



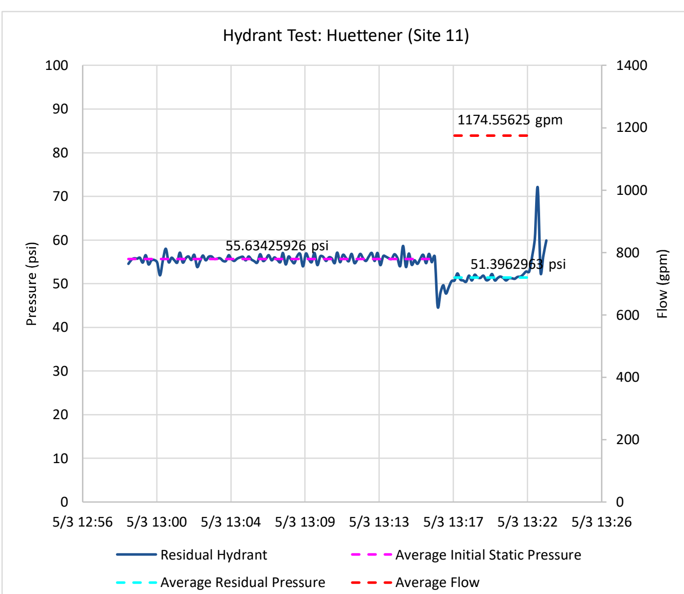
GARVER

Flow Testing Field Data Sheet

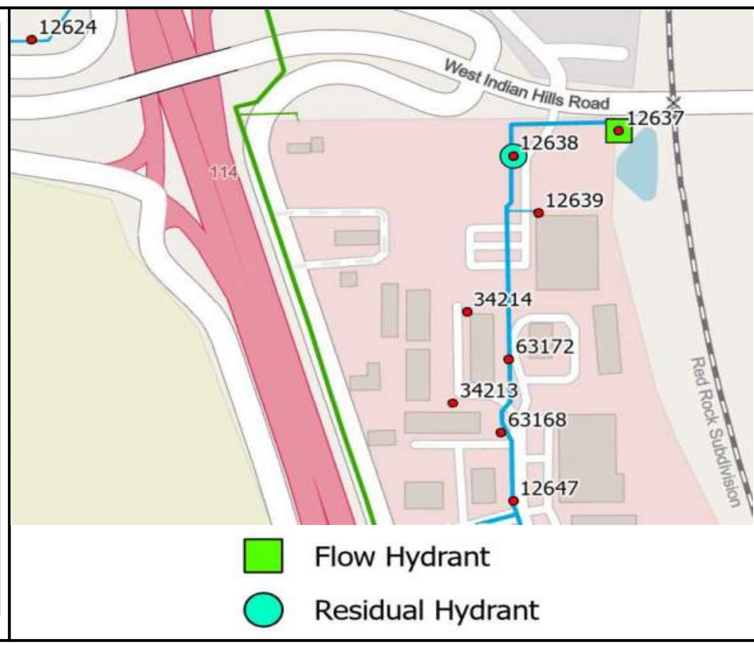
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**11**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**WEST INDIAN HILLS ROAD (TIMBER CREEK FELLOW CHURCH)**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 **No.** 12637	**12638**	**56**		**1:17**	**49**	**51 psi**	**1:22**
Hydrant 2 (if needed) **No.**							

Chart:



Vicinity Map:



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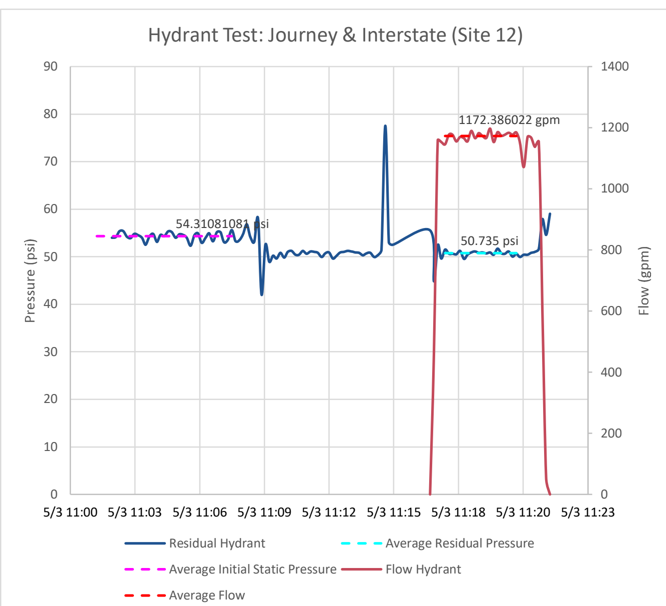
Flow Testing Field Data Sheet

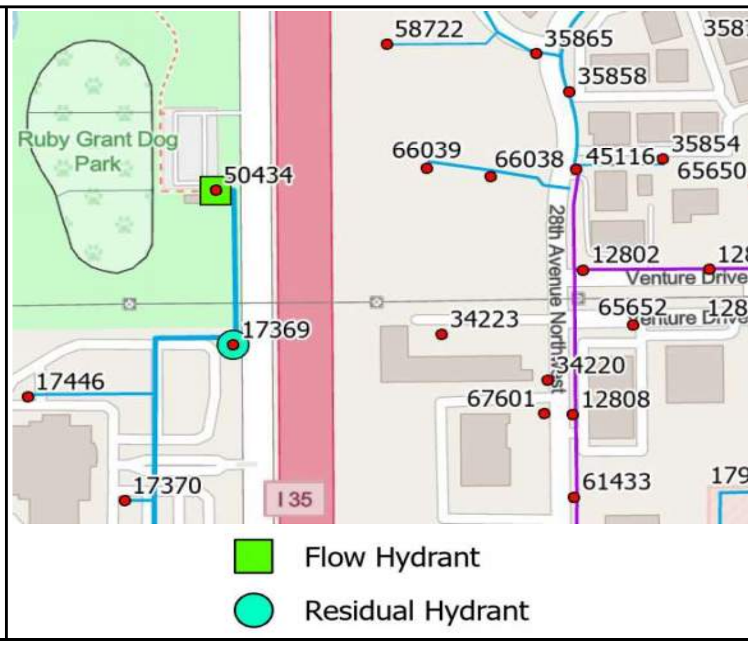
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**12**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**RUBY GRANT DOG PARK AND DISC GOLF**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 50434	**17369**	**52**		**11:17**	**51 psi**	**50**	**11:20**
Hydrant 2 (if needed) No. ______________							

Chart:



Vicinity Map:

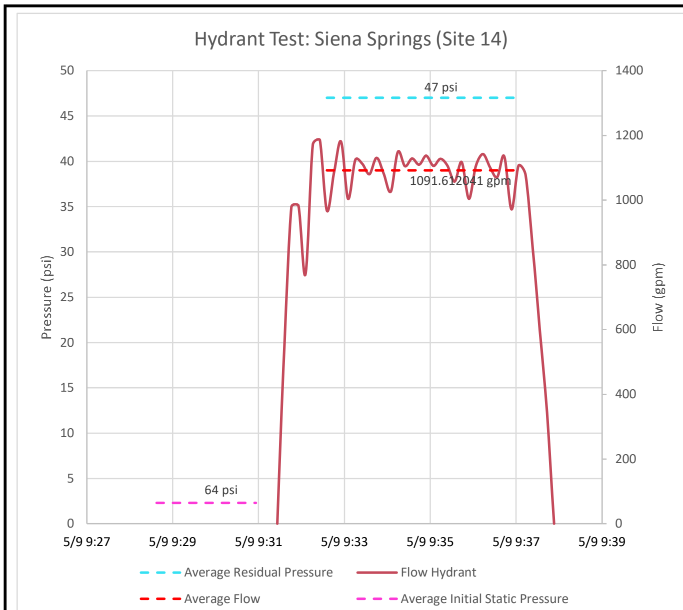


Flow Testing Field Data Sheet

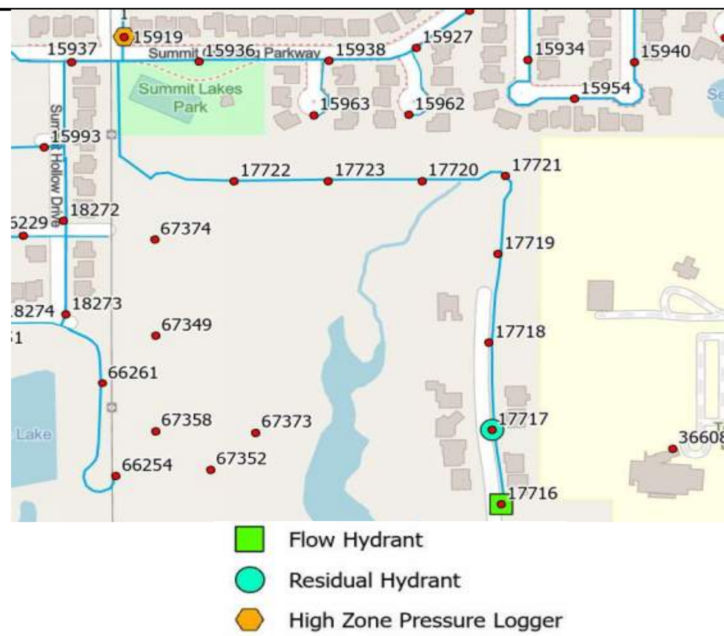
Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**13**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	M. NGUYEN
Location/Address:	**NORTH OF EAST LINDSEY STREET & SIENA SPRINGS DRIVE**		

Flow Test Information							
Flow Hydrant	**Test Hydrant No.**	**Test Hydrant Static Pressure (psi)**	**Flow Outlet Nozzle Size (in)**	**Time Opened**	**Pitot Gauge Pressure (psi)/Flow Reading (gpm)**	**Test Hydrant Residual Pressure (psi)**	**Time Closed**
Hydrant 1 No. 17716	**17717**	**64**		**9:18**	**45**	**47**	**9:23**
Hydrant 2 (if needed) No. ___________							

Chart:



Vicinity Map:



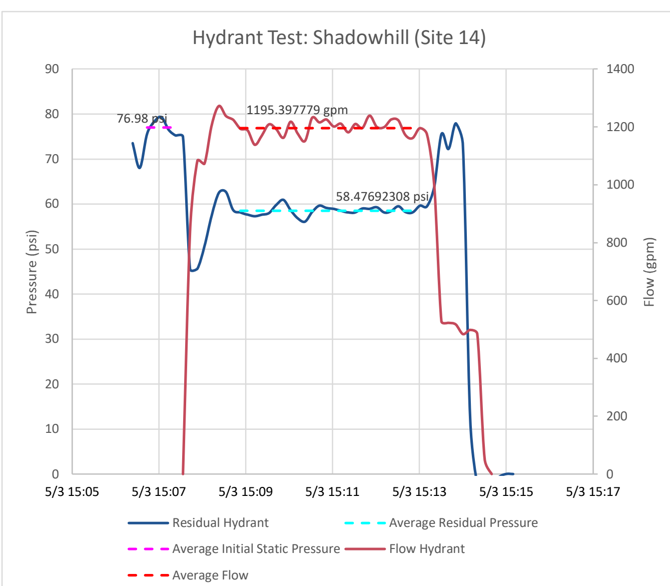
Flow Testing Field Data Sheet

Project/Site Information			
Project Number:	**22W02320**	**Project Name:**	**City of Norman Area & Infrastructure Master Plan**
Site Number:	**14**	**Client:**	Norman Utilities Authority
Site Name:		**Completed by:**	
Location/Address:	**SHADOWHILL STREET**		

Flow Test Information

Flow Hydrant	Test Hydrant No.	Test Hydrant Static Pressure (psi)	Flow Outlet Nozzle Size (in)	Time Opened	Pitot Gauge Pressure/Flow Reading (gpm)	Test Hydrant Residual Pressure (psi)	Time Closed
Hydrant 1 No. ____________		77		10:09	47	57	10:14
Hydrant 2 (if needed) No. ____________							

Chart:



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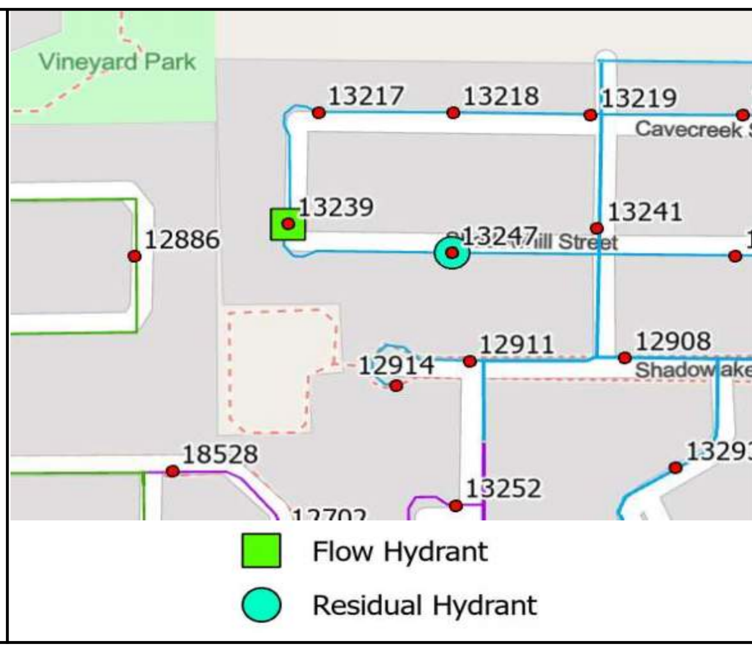

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APPENDIX D

2060 STRATEGIC WATER SUPPLY PLAN

PAGES 61-172

SOURCE OPTION CHARACTERIZATION AND INITIAL SCREENING

The individual water supply sources evaluated as part of this project are listed in Table 3.1 below. The new local and outside (or regional) sources were characterized and compared using preliminary screening criteria, described in Section 3.4. Based on results of the initial screening, the most viable new sources along with Norman's existing sources were used to develop water supply portfolios (i.e., "packages" of supplies that together will meet Norman's future water demands) as detailed in Section 5.

Table 3.1 Water Supply Sources Evaluated for 2060 SWSP(1)
Existing Sources • **Lake Thunderbird (at firm yield)(2)** • **Garber-Wellington Aquifer Wells (with treatment)** • **Water Conservation and Reuse** • **Purchase Treated Water from Oklahoma City (wholesale)**
New Local Sources • **Additional Water Conservation** • **Additional Non-potable Water Reuse** • **Lake Thunderbird Augmentation (indirect potable reuse)** • Stormwater Capture and Reuse • Canadian River Diversion • Lake Thunderbird Spillage • Groundwater Recharge (indirect potable reuse)
New Regional Sources • **Co-owner with Oklahoma City for Southeast Oklahoma Treated Water** • **Co-owner with Oklahoma City for Southeast Oklahoma Raw Water** • **Scissortail Reservoir** • **Parker Reservoir** • **Kaw Lake**
Notes: (1) Most viable sources retained for portfolio evaluations are indicated in bold font. (2) Includes consideration of dredging the lake or raising the dam for additional storage.

The following key assumptions were made to evaluate the individual water supply sources.

- Firm yield (the amount of water Norman could rely on in an extended drought) was estimated on the following basis:
  - If the source has available firm yield that is equal or greater than Norman's projected 2060 annual average day demand (29.1 mgd), the yield was set at 29.1 mgd.

- If the source has available firm yield that is less than Norman's projected 2060 annual average day demand (29.1 mgd), the yield was set equal to the maximum amount of firm yield available from that source.
- For certain supply sources, the firm yield was set lower than the maximum available supply based on balancing yield with costs. An example of this is the capture of Lake Thunderbird spillage. For the 2060 SWSP, the spillage was limited to 20 percent of Norman's projected 2060 demands even though more supply could be captured. The cost Lake Thunderbird spillage is high (relative to other supply sources).
- For certain supply sources, the firm yield was set lower than the maximum available supply based on potential customers' projected water use. For example, non-potable reuse supply was limited to the projected needs of likely customers. Costs for treatment and infrastructure closely match the anticipated demand for this source water

* Lake Thunderbird cannot be reliably used for terminal storage of new local or regional supplies, because its conservation pool is at times already full from storage of runoff from its tributary watersheds. If a water supply needs storage to secure firm yield or minimize size of raw water conveyance infrastructure, a new terminal storage reservoir is included in the source cost. The exception to this assumption is Lake Thunderbird augmentation, which does "store" reclaimed water in the reservoir. Storage of reclaimed water in the reservoir can be managed to increase the yield of the lake, taking advantage of low lake levels by managing the timing and quantity of flows pumped from Norman's Water Reclamation Facility (WRF) to Dave Blue Creek.
* Terminal storage sizing is based on a mass balance calculation that accounts for inflows, withdrawals, and evaporation. Calculations are performed on a monthly time step. Terminal storage was sized to provide a reliable annual yield from each source. It was assumed that reliability (i.e., a firm yield that would be available even in multi-year droughts) is paramount for each source, to avoid the need for redundant supplies to cover times when the source would be unable to provide the intended yield.
* Pipelines were sized to achieve a maximum in-pipe flow velocity of 6 feet per second (fps).
* Treatment capacity is based on Norman's recent usage trends (with peak day demands equal to 1.9 times annual average demands), except for non-potable reuse that is based on irrigation users' unique demand patterns (i.e., high summer peak demands).
* Treatment process selection was based on available water quality information. In the absence of historical water quality data, assumptions are made given general knowledge of source water quality.
* To provide a consistent basis of comparison, unit costs for pipelines, pump stations, reservoir, storage, and treatment were used to develop project costs for each supply source, described in Section 2.6.

- Water availability for regional sources was assessed using data from the 2012 Update of the Oklahoma Comprehensive Water Plan, as revised in early 2013 (OWRB 2013), including relevant Watershed Planning Region Reports and basin-level data.

The sections below summarize individual water supply sources that were evaluated as part of the 2060 SWSP. More detailed information on each source is available in Appendices A and C through Q.

3.1 EXISTING SOURCES

This section describes existing water supply sources used by NUA and modifications necessary for the continued use of these sources. Existing water conservation and reuse programs were assumed to continue at their current levels. Additional water conservation and water reuse measures are examined in Section 3.2 as new local sources.

3.1.1 Lake Thunderbird

Lake Thunderbird is located in OCWP Central Watershed Planning Region, Basin 62. The lake is entirely located within Norman’s city limits. Construction was completed by the U.S. Department of Interior’s Bureau of Reclamation (BOR) in 1965. Lake Thunderbird is managed by COMCD for the benefit of its member cities Norman, Del City, and Midwest City. The lake’s water supply yield is shared between Norman, Del City, and Midwest City in proportion to their cost obligation in constructing the dam. Norman’s allocation is 43.8 percent of the permitted yield for Lake Thunderbird. Midwest City’s allocation is 40.4 percent, and Del City has the remaining 15.8 percent of the total allocation.

3.1.1.1 <u>Description of Current Use</u>

Lake Thunderbird currently is permitted based on its conjunctive yield, which is defined as the total of firm yield from Lake Thunderbird plus water from the Garber-Wellington Aquifer that supplements the supply during summer peaks and times of drought. This conjunctive yield was originally established at 21,600 AFY. This corresponds to an allocation for Norman equal to 9,460.8 AFY (or 8.45 mgd average). Midwest City and Del City have not always utilized their full allocation; however, Norman has exceeded its allocation 17 times in the last 25 years. Norman’s 25-year average annual withdrawal is 9,951 AF or 8.88 mgd on average. The peak daily withdrawal for Norman is 15.99 mgd, which occurred on August 2, 1999.

Water from Lake Thunderbird is pumped to NUA’s Vernon Campbell WTP through approximately 6 miles of 33-inch concrete pipe followed by approximately 2.5 miles of 30-inch concrete pipe. NUA recently paralleled the existing 30-inch portion with a new 48-inch fiberglass pipeline. The increase in transmission capacity will remove the hydraulic constraint on the Thunderbird raw water supply compared to the WTP capacity. This 48-inch pipeline is anticipated to be in service in the fourth quarter of 2013. With the new pipeline in service, the peak raw water transmission capacity for Lake Thunderbird supplies will be 17 mgd.

The Vernon Campbell WTP has a peak treatment capacity of 17.0 mgd and utilizes conventional treatment with softening. It will be rehabilitated within the next 5 years under the “Phase II WTP upgrades” to address water quality issues related to new regulatory mandates and to mitigate taste and odor events. According to the City’s budgetary figures, the Phase II upgrades are expected to cost approximately $33 million, and funds have been allocated to cover these expenses.

3.1.1.2 Impacts on Continued Use

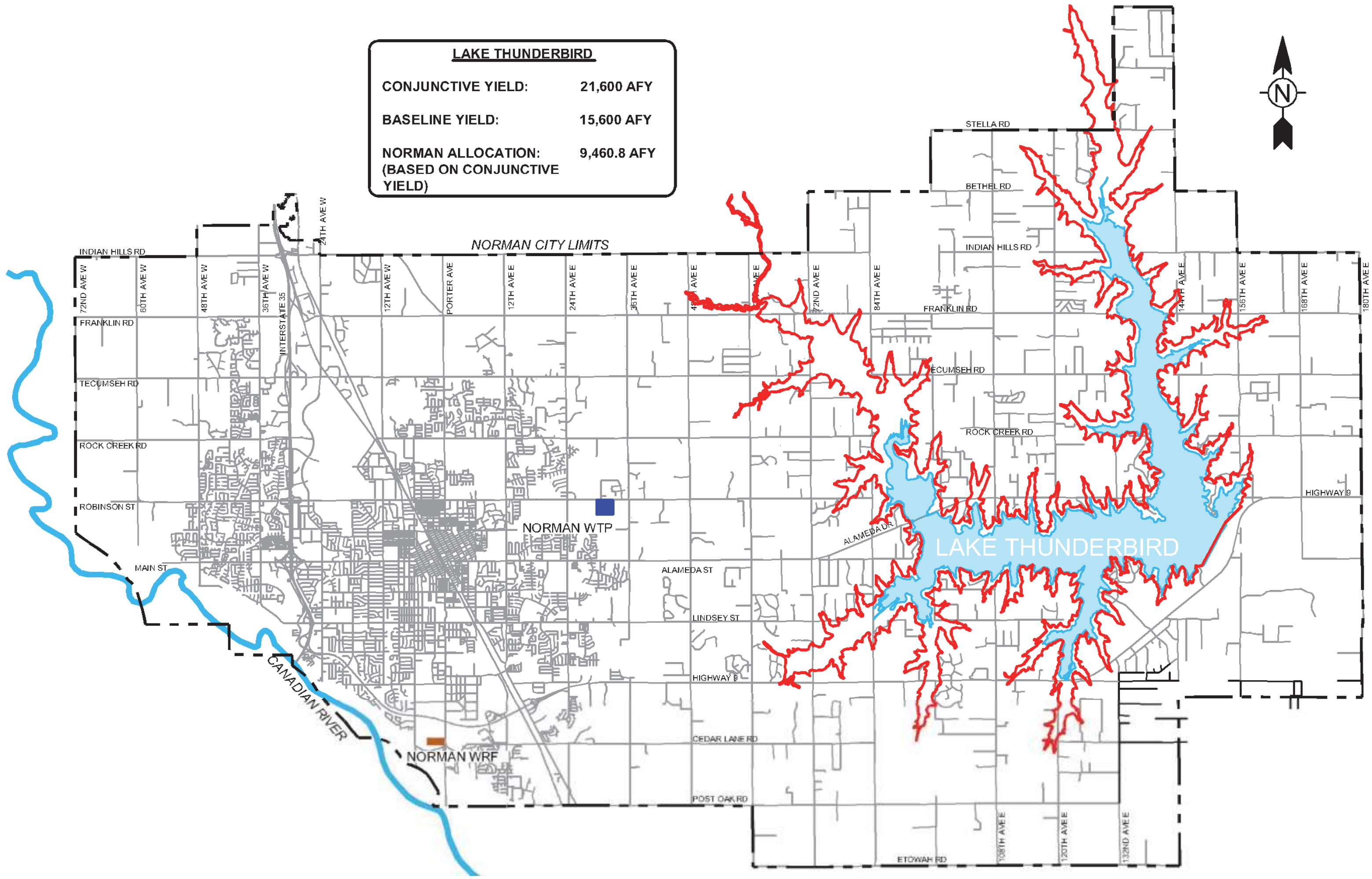
To eliminate double counting of groundwater yields and clarify the expected firm yield of the lake without groundwater, the BOR and COMCD are considering modifications to the member cities’ Lake Thunderbird supply allocations. It is anticipated that the total of the revised allocations will be equal to the firm yield for the lake. The BOR has previously calculated the firm yield at 15,600 AFY.

This could reduce Norman’s allocation to 6,833 AFY (6.1 mgd annual average). For the 2060 SWSP, a reduced allocation of 6.1 mgd was assumed for evaluation and planning purposes and it was assumed that a reduced allocation would go into effect in 2016.

3.1.1.2.1 *Raising the Norman Dam*

Raising the Norman Dam to increase available water supply was considered as a potential means of increasing supplies from Lake Thunderbird. It is estimated that for each foot of dam height added, approximately 6,000 AF of storage could be gained.

As an initial basis of analysis, several supply options were considered in terms of their ability to meet at least 20 percent of NUA’s projected 2060 annual average demand (29.1 mgd), i.e., 5.8 mgd. In order to recognize an additional 5.8 mgd of firm yield from Lake Thunderbird, the conservation pool elevation would need to be increased from 1,039 feet above mean sea level (MSL) to 1,051.5 feet MSL. This would expand the surface area of Lake Thunderbird as shown in Figure 3.1. The amount of infrastructure required to capture this water and extent of property impacted within the inundated area are significant concerns. Additionally, it is unknown if the existing earthen dam can be raised without reconstruction. Land acquisition costs, road and bridge reconstruction costs, and dam reconstruction costs are expected to be very high. Given the uncertainties, significant property impacts to adjacent development, and costs, raising the dam was not considered a viable option within the planning period and is not considered further. However, as the reservoir approaches its useful life toward the end of the SWSP planning period, significant dam and outlet works rehabilitation may be required. Raising the dam could be reconsidered in conjunction with those efforts.



EL=1049 EXISTING TOP OF FLOOD CONTROL POOL
EL=1062 NEW TOP OF FLOOD CONTROL STORAGE POOL
EL=1068 EXISTING TOP OF SURCHARGE POOL
EL=1081 NEW TOP OF SURCHARGE POOL
EL=1071 EXISTING DAM CREST
EL=1084 NEW DAM CREST
Norman Water Treatment Plant
Norman Water Reclamation Facility

LAKE THUNDERBIRD INUNDATION MAP

FIGURE 3.1

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

3.1.1.2.2 *Dredging Lake Thunderbird*

Dredging Lake Thunderbird also was considered as a potential means of increasing yield from the reservoir. The BOR's firm yield calculations for Lake Thunderbird assumed that storage equal to 100 years of sediment accumulation is unavailable for water storage. Recent bathymetric surveys indicate that the sediment accumulation to date closely tracks with the projected sedimentation rate. Dredging a reservoir is a very expensive and unproven approach, and requires a considerable amount of land to dry and dispose of the dredged material. Moreover, dredging would provide only temporary storage and yield benefits, until such time as sedimentation re-filled the dredged volume. Dredging Lake Thunderbird is not considered a viable option for the 2060 SWSP planning period. Similar to raising the dam, significant dam and outlet works rehabilitation may be required in the future, and dredging could be reconsidered in conjunction with those efforts.

3.1.1.3 Opinion of Costs

There are no new capital costs associated with continued use of Lake Thunderbird for storage through the 2060 SWSP planning period, other than rehabilitation and maintenance. Norman's debt on Lake Thunderbird and Norman Dam is paid for in full. However, the Norman Dam will require rehabilitation or partial reconstruction in the coming years. Until a more in depth study is performed on the current condition of the dam, rehabilitation costs are relatively unknown. Additionally, lakeshore maintenance or rehabilitation may be required in the next 50 years. Finally, as the reservoir reaches the end of its anticipated service life, consideration must be given to either dredging the lake or raising the dam in order to maintain its firm yield or the firm yield must be reduced to account for reaching the siltation limit allowed in the yield study. These costs are not included in this study, as they will be common to any future use of the lake. Continued use of Lake Thunderbird was included as a component of each 2060 SWSP recommended portfolio, as detailed in the remaining sections of this report.

3.1.1.4 Summary of Individual Source

Table 3.2 summarizes information regarding the continued use of Lake Thunderbird. Other than the reduction in permitted withdrawal amount (based on the actual firm yield of the reservoir) and rehabilitation/maintenance activities, there are no significant challenges with continued use of Lake Thunderbird through the 2060 planning horizon. However, rehabilitation and replacement of Norman's infrastructure for diversion, conveyance, and treatment of Lake Thunderbird supplies was included in the detailed financial analyses of the recommended portfolios. Costs associated with augmenting Lake Thunderbird supplies were considered separately.

Table 3.2 Existing Water Supply Source – Lake Thunderbird		
Existing Yield Available to Norman[1]	AFY	9,461
	mgd	8.45
Anticipated Future Firm Yield Available to Norman[2]	AFY	6,833
	mgd	6.1
Percent of projected 2060 demands supplied by firm yield[3]	Percent	21
Raw Water Transmission Distance	Miles	8.5
Water Treatment Process		Conventional with softening
Known Long-term Reliability Issues		Dam maintenance/rehabilitation
Known Implementation Issues		None
Opinion of Capital Costs	2012 $	$0
Unit Capital Cost of Source[4]	$/AFY	$0

Notes:

(1) Existing yield based on Norman's portion of Lake Thunderbird conjunctive yield.
(2) Firm yield based on Norman's portion of Lake Thunderbird's firm yield.
(3) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(4) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(5) Summed and converted values may vary slightly due to rounding.

3.1.2 Garber-Wellington Aquifer Wells

The OCWP characterized the Garber-Wellington Aquifer as follows (OWRB, 2013):

- Underlies a large portion of central Oklahoma and is considered a major bedrock aquifer;
- Consists of fine-grained sandstone interbedded with siltstone and shale;
- Has generally good water quality, but in some areas, concentrations of nitrate, arsenic, chromium, and selenium may exceed drinking water standards; and
- Is administered via temporary permits under an equal proportionate share (EPS) of 2.0 AFY per acre of land dedicated to the wells.

OWRB is currently conducting a study of the Garber-Wellington Aquifer that is expected to result in a reduction to the EPS. The Garber-Wellington Aquifer has an estimated recharge rate of 1.6 inches per year (OWRB, 2013), but Oklahoma water law allows EPS to be set at rates greater than the rate of recharge. The final EPS approved by OWRB in light of the study will govern the future permanent permits and may require NUA to dedicate more land to its existing wells to maintain their permitted capacity.

3.1.2.1 Description of Current Use

NUA operates 36 active bedrock groundwater wells in the Garber-Wellington Aquifer. In addition, NUA owns 12 groundwater wells that are offline (inactive) because of levels of arsenic that exceed the regulatory maximum contaminant level (MCL) limit of 10 parts per billion (ppb or µg/L). Of these 12 inactive wells, one was repurposed for irrigation at Griffin Park and at one NUA operates a wellhead arsenic removal project (effectively, there are 10 wells available to be reinstated if treatment is provided).

The active wells are estimated to have an annual average yield of approximately 6,720 AFY (or 6.0 mgd annual average). Historical flow data indicate that approximately 9.0 mgd can be achieved during maximum withdrawal rates from active wells; however, this rate cannot be continuously maintained (as indicated by reduced well production rates after periods of running at higher aquifer pumping rates). NUA has observed recovery in water table levels and well yields after reducing pumping rates, suggesting an ability of the aquifer to recover from intensive pumping activity.

The inactive wells are estimated to have an annual average yield of approximately 2,340 AFY (or 2.1 mgd annual average). Historical flow data indicates that approximately 2.7 mgd can be achieved during maximum withdrawal rates; however, this rate cannot be continuously maintained due to close spacing of some of the inactive wells and reduced well production rates after periods of running at these higher rates.

Available data for arsenic and chromium-6 concentrations in water pumped from the existing wells were reviewed. A summary of the available data, including the well identification number, the well flow rate, the arsenic concentration, and the chromium-6 concentration for the 48 wells is summarized in Table 3.3.

Currently, total chromium is regulated by the EPA with an MCL of 100 ppb, and no specific limit has been set for chromium-6. It is anticipated that EPA will release a draft assessment for chromium-6 for public comment that could set a path toward establishing a future MCL for chromium-6. The effect of a range of potential future MCLs for chromium-6 was investigated and is summarized in Section 3.1.2.2.

3.1.2.2 Impacts on Continued Use

There are several factors that affect the continued use of the Garber-Wellington Aquifer wells as a water source. Changes to the permitted withdrawal rate, anticipated regulations on chromium-6, and options to address existing arsenic regulations are discussed in this section.

Table 3.3 Garber-Wellington Aquifer Well Data			
Well No.(3)	**Average Flow Expected (gpm)(2)**	**Arsenic Concentration (ppb)(2)(4)**	**Chromium-6 Concentration (ppb)(1)(2)**
1	161	637	58.5
2	224	8.3	58.5
3A	121	3.6	43
4(1)	249	20-100	--
5	146	N/A	74
6	190	6.9	37
8	225	6.1	55
11(1)	112	45-90	--
12(1)	164	90-100	--
13(1)	190	30	--
14(1)	177	30-80	--
15(1)	215	15-50	--
16(1)	143	15-30	--
18(1)	136	10-20	--
19	191	4.5	23
20	144	8.7	32.5
21(1)	144	20-50	--
31	159	4.9	32.7
32(1)	182	20-40	--
33	214	6.4	65
34	162	<2	55
35	142	<2	51.5
36	82	<2	70.5
37	120	<2	52.5
38	189	<2	36
39	197	9.8	79.5
40	168	5	45
HP2(1)	150	>200	--
HP3(1)	160	37	--
41	179	3.9	32
43	173	<2	28.7

Table 3.3 Garber-Wellington Aquifer Well Data			
Well No.(3)	**Average Flow Expected (gpm)(2)**	**Arsenic Concentration (ppb)(2)(4)**	**Chromium-6 Concentration (ppb)(1)(2)**
44	167	<2	6.3
45	146	<1	67
46	216	2.4	51
47	179	<2	9
48	145	8.8	94.3
49	202	5	89.2
51	150	<10	18
54	117	<10	50
55	150	<10	27.7
56	120	<5	14
57	167	<10	47.7
58	150	<10	26
59	325	<10	45.3
60	240	<10	38.1
61	200	6	46.2
Total	**7,883(5)**	**N/A**	**N/A**

<u>Notes:</u>

(1) Indicates inactive well due to arsenic levels. Arsenic levels reported include the range of arsenic samples recorded at different times. Chromium-6 data were not available for inactive wells.

(2) Flow, arsenic concentration, and chromium-6 concentration data were provided by City staff based on historical readings and trends.

(3) Well 23 is used for irrigation and Griffin Park and is not available as a future water supply.

(4) “<” or less than means that the sample result was lower than the detection limit of the testing method. Similarly,” >” or greater than means that the sample result was higher than the detection limit of the testing method.

(5) The total historical average flow from the active and inactive wells is approximately 11.3 mgd. However, based on discussions with staff, average annual and peak day supplies of 6.0 and 9.0 mgd from active wells and 2.1 and 2.7 mgd from inactive wells were used in the SWSP.

As mentioned previously, OWRB is conducting a study on the Garber-Wellington Aquifer that is expected to replace the temporary EPS of 2.0 AFY per acre with a lower permanent value. No definitive information is available on what the new EPS will be, but under Oklahoma water law, Norman could dedicate more land to its well permits in order to compensate for a reduction in the EPS. Based on preliminary feedback of possible permanent EPS values and calculations of land that Norman could dedicate to its wells, permitted withdrawal is not expected to limit Norman’s ability to use its existing active and inactive Garber-Wellington Aquifer wells.

EPA issued the final Arsenic Rule in January 2001 and it became fully effective in June 2006. The rule applies to all public water suppliers (PWS) regardless of size. The revised rule establishes an unenforceable MCL goal (MCLG) of zero and an enforceable MCL of 10 μg/L. Norman has 12 wells offline due to elevated arsenic levels. The 2060 SWSP evaluated bringing the currently inactive wells back online using appropriate treatment to remove arsenic and chromium-6 to below current arsenic standards and assumed future chromium-6 standards.

Total chromium (sum of trivalent chromium and chromium-6) is regulated by EPA with an MCL of 100 μg/L. There is currently no specific limit for chromium-6. California issued a MCL for chromium-6 of 10 μg/L in 2014. While it is unclear when EPA will develop a MCL or what the MCL level will be, it is prudent in long-term planning to address the potential issue of treating chromium-6 in the Garber-Wellington Aquifer wells. For purposes of the 2060 SWSP, based on available information and industry insights, it was assumed that federal MCL for chromium-6 would become effective in 2018. The effect of potential future MCLs for chromium-6 of 20 ppb, 10 ppb, and 5 ppb was investigated.

- A future MCL of 20 ppb would result in all but four of the existing active wells exceeding the MCL, or a maximum potential loss of 5,560 gpm (8.0 mgd). This would reduce the groundwater source to approximately 650 gpm (0.9 mgd) if treatment were not implemented.
- A future MCL of 10 ppb would result in all but two of the existing active wells exceeding the MCL, or a maximum potential loss of 5,850 gpm (8.4 mgd). This would reduce the groundwater source to approximately 350 gpm (0.5 mgd) if treatment were not implemented.
- A future MCL of 5 ppb would result in all of the existing active wells exceeding the MCL, or a maximum potential loss of 6,200 gpm (8.9 mgd). Without treatment, this would likely eliminate the use of all Garber-Wellington Aquifer wells for potable supply in Norman.

For the 2060 SWSP, a new centralized treatment plant was evaluated to address both arsenic (at its MCL of 10 μg/L) and chromium-6 (at an assumed future MCL of 5 μg/L). While most of NUA's wells do not require treatment for arsenic, a need to implement treatment of virtually all wells would be driven by such a chromium-6 standard. This presents an opportunity to use the new raw water collection piping and groundwater treatment facility to also convey and treat water from wells currently inactive because of arsenic. This approach leverages NUA's past investments in both existing active and inactive well infrastructure.

It is anticipated that ion exchange using media specific to arsenic and chromium-6 removal will be employed in series, followed by chlorination prior to entering the water distribution system. More information on possible arsenic and chromium-6 treatment is available in Appendix D. Treatment selection was based on local projects for arsenic removal and ongoing assessments of chromium-6 treatment at Glendale Power and Light in California (Norman, 2002, Norman, 2010 and WRF, 2011).

Upon implementation of federal chromium-6 MCLs, all of NUA's groundwater would be conveyed through a network of new untreated well water collection piping to a single common treatment facility, a new centralized North Water Treatment Plant, before being distributed to customers. Figure 3.2 illustrates the modifications needed to continue use of this source.

Detailed WTP siting investigations were not conducted in the 2060 SWSP. A general location for a centralized treatment plant was assumed in order to determine approximate pipeline lengths that would be required to convey untreated well water to the new WTP and from seven southern wells to the existing Vernon Campbell WTP. It is estimated that approximately 40 miles of new untreated well water pipelines will be required. The majority of the pipelines will be 12 inches in diameter, feeding into larger mainlines that terminate at the new North WTP. The required capacity of the new WTP is estimated to be 10.4 mgd, which covers the assumed maximum daily withdrawal of the active and inactive well field, not including 1.5 mgd of capacity from seven southern wells. The seven southern groundwater wells are assumed to be blended with treated surface water from NUA's existing Vernon Campbell WTP to meet the arsenic and anticipated chromium-6 MCLs.

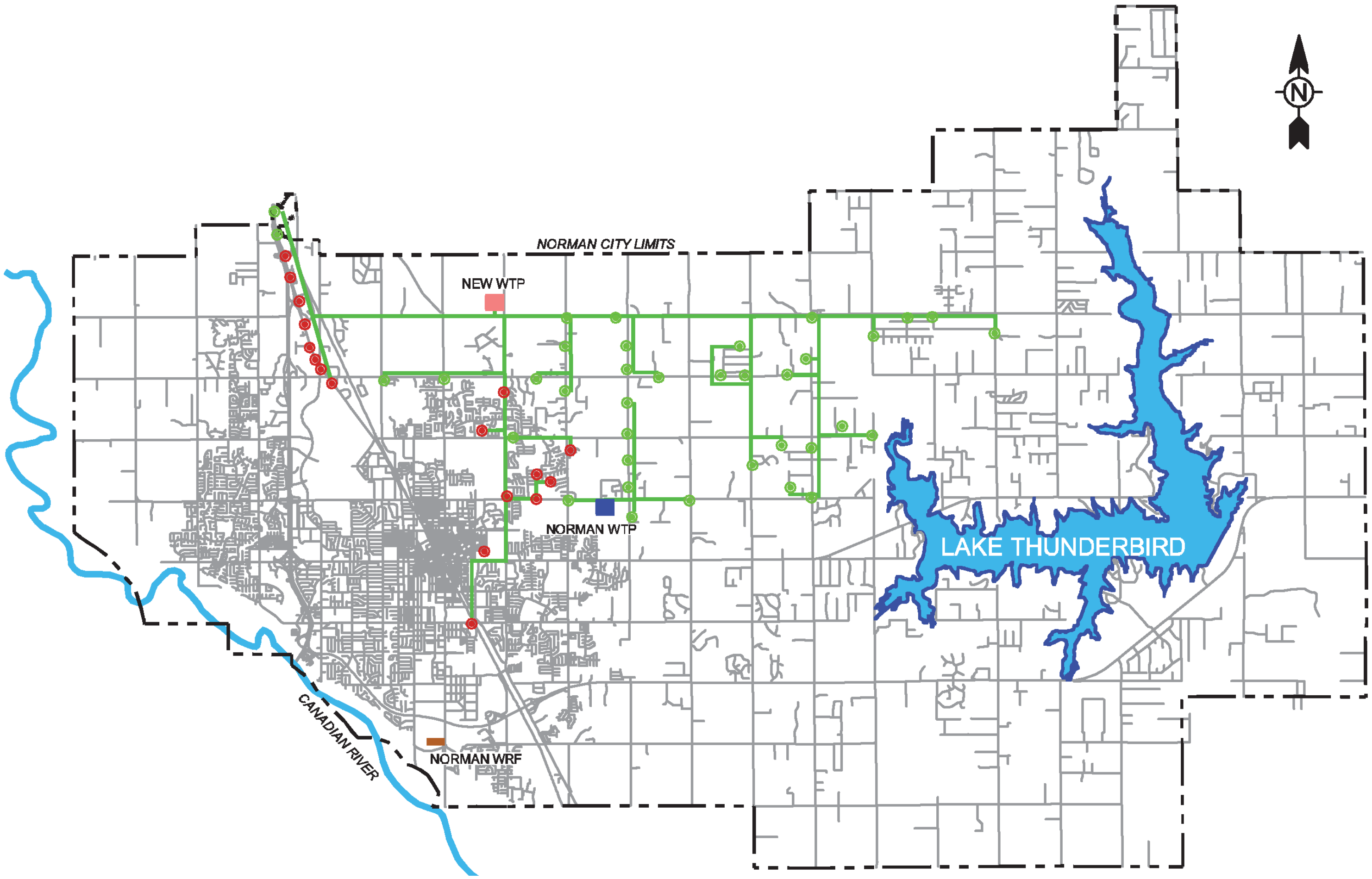
3.1.2.3 Opinion of Costs

Capital costs for continued use of the Garber-Wellington Aquifer include costs for a new raw water collection system to convey water from each well to a new centralized North WTP and for water from seven wells to be conveyed to the Vernon Campbell WTP site. Additionally, costs were developed for drilling new wells for scenarios that included expansion of wellfield production (again assuming treatment for arsenic and chromium-6 at the North WTP, with expanded treatment capacity as appropriate). Costs were based on assumptions listed in Section 2.6.

3.1.2.4 Summary of Individual Source

Table 3.4, Table 3.5, and Table 3.6 summarize information regarding the continued use of the Garber-Wellington Aquifer by category:

- Existing Garber-Wellington Aquifer wells with centralized treatment.
- Bringing currently inactive Garber-Wellington Aquifer wells online using centralized treatment.
- New Garber-Wellington Aquifer wells with centralized treatment.



Active Water Well
Inactive Water Well
New Raw Water Line
Norman Water Treatment Plant
Norman Water Reclamation Facility

CONCEPTUAL GARBER-WELLINGTON AQUIFER WELLS WITH CENTRALIZED TREATMENT

FIGURE 3.2

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

carollo — TETRA TECH

pw://Carollo/Documents/Client/OK/Norman/8956A00/Deliverables/Report/Fig03_02.docx (Final)

Table 3.4 Existing Water Supply Source – Active Wells with Arsenic and Chromium-6 treatment at Centralized WTP		
Existing Yield Available to Norman	AFY	6,721
	mgd	6.0
Proposed Firm Yield Available to Norman	AFY	6,721
	mgd	6.0
Percent of projected 2060 demands supplied by firm yield(1)	Percent	21
Raw Water Transmission Distance	Miles	34.2
Water Treatment Process(3)		Arsenic and chromium-6 removal followed by chlorination
Known Long-term Reliability Issues		Concerns about withdrawing water at unsustainable rate
Known Implementation Issues		Unknowns regarding future water quality trends and regulations on chromium-6 and other possible contaminants
Opinion of Capital Costs	2012 $	$68,300,000
Unit Capital Cost of Source(2)	$/AFY	$10,200

Notes:

(1) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).

(2) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.

(3) Seven southern wells will be blended with finished water from the Norman WTP. All other existing wells will receive treatment listed.

(4) Summed and converted values may vary slightly due to rounding.

Table 3.5 Existing Water Supply Source – Inactive Wells with Arsenic and Chromium-6 treatment at Centralized WTP

Existing Yield Available to Norman	AFY	0
	mgd	0
Proposed Firm Yield Available to Norman	AFY	2,341
	mgd	2.1
Percent of projected 2060 demands supplied by firm yield(1)	Percent	7
Raw Water Transmission Distance(4)	Miles	6.5
Water Treatment Process		Arsenic and chromium-6 removal followed by chlorination
Known Long-term Reliability Issues		Concerns about withdrawing water at unsustainable rate
Known Implementation Issues		Unknowns regarding future water quality trends and regulations on chromium-6 and other possible contaminants
Opinion of Capital Costs	2012 $	$17,600,000
Unit Capital Cost of Source(2)	$/AFY	$7,500

Notes:

(1) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(2) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(3) Summed and converted values may vary slightly due to rounding.
(4) Assumes that the active well raw water collection system has been established and inactive wells will connect to this system.

Table 3.6 Existing Water Supply Source – One New Well with Arsenic and Chromium-6 treatment at Centralized WTP		
Existing Yield Available to Norman	AFY	0
	mgd	0
Proposed Firm Yield Available to Norman	AFY	187
	mgd	0.2
Percent of projected 2060 demands supplied by firm yield(1)	Percent	1
Raw Water Transmission Distance(4)	Miles	1
Water Treatment Process		Arsenic and chromium-6 removal followed by chlorination
Known Long-term Reliability Issues		Concerns about withdrawing water at unsustainable rate
Known Implementation Issues		Unknowns regarding future water quality trends and regulations on chromium-6 (and other possible contaminants)
Opinion of Capital Costs	2012 $	$2,600,000
Unit Capital Cost of Source(2)	$/AFY	$14,100

Notes:
(1) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(2) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(3) Summed and converted values may vary slightly due to rounding.
(4) Includes costs to drill and equip new wells. Assumes that the active well raw water collection system has been established and new wells will connect to this system.

3.1.3 Purchase Treated Water from Oklahoma City (Wholesale)

Since 2000, Norman has occasionally purchased treated (also referred to as "finished") water from Oklahoma City, primarily to meet peak day demands. This section describes the current use of wholesale water from Oklahoma City and long-term options for using this source.

3.1.3.1 Description of Current Use

Norman has a 12-inch turbine meter that can receive treated water from Oklahoma City via a 24-inch water main. This connection is located near the northwest boundary of the Norman City limits. The amount of water available through this connection varies based on the pressure differential between the Oklahoma City and Norman distribution systems, but is estimated to have a maximum capacity of 9.0 mgd and an average capacity of 6.0 mgd.

The amount of treated water NUA purchases from Oklahoma City varies from year to year. It is only used when Norman's local water sources cannot meet system demands, and is generally the last source NUA chooses to use since its cost is greater than what Norman's current rate structure would support on a continual basis. Typically, this has resulted in purchases of Oklahoma City water during the summer months to meet peak day demands. The amount of water purchased has fluctuated significantly from year to year, ranging from as little as 2.4 million gallons in calendar year 2004 to as many as 227 million gallons in calendar year 2006, with an average annual purchase of approximately 70 million gallons between 2000 and 2011. Using historical data between 2000 and 2012, the highest recorded single day water purchase was 7.35 million gallons.

Norman currently purchases treated water from Oklahoma City under Oklahoma City's designated Demand Service Plan. Under this plan, there is no minimum monthly usage that the customer is obligated to use (or pay for), but the per-gallon fees are the highest of the three wholesale plans offered by Oklahoma City. Currently, Oklahoma City has three different water service plans that municipal water users can select from: the Demand Service, Take-or-Pay, and Service Availability. Appendix F has more information on available Oklahoma City wholesale water service plans and associated fee structures. Oklahoma City is planning to revamp its wholesale rate structures, which will affect the cost to Norman for use of these supplies. The revised rate structures will be phased in over the next few years.

3.1.3.2 Impacts on Continued Use

If Norman continues to purchase treated water as a wholesale customer to Oklahoma City, it is important for Norman to consider how best to use this source. Currently, Norman is using treated Oklahoma City water intermittently under the Demand Service Plan, Oklahoma City's highest wholesale water rate. This plan is appropriate for Norman's current strategy of purchasing Oklahoma City water only when necessary and minimizing the overall annual cost of treated water purchases.

Long-term, however, Norman may choose to rely on this source to meet its water needs differently, relying on water from Oklahoma City to meet a year-round, or "base load" demand, instead of using it exclusively for peak day supplemental supply. Under the Service Availability Plan, Norman could purchase a more consistent amount of water (to support average day needs) taking advantage of lower rate structures. Under the Service Availability Plan, Norman's strategy for Oklahoma City water purchases must be one that includes a predetermined minimum amount of water to be purchased each month.

Regardless of which purchasing plan is selected, Oklahoma City wholesale rates are expected to increase more rapidly than overall rates of inflation. In Oklahoma City's latest water rate ordinance, Oklahoma City laid out rates for fiscal years 2010-2014, and in each year rates increased by approximately 4 percent (Oklahoma City, 2010). Beyond 2014, Oklahoma City has not set water rates. Its rates are expected to increase annually by 4 percent to 7 percent for at least the next 10 years to accommodate Oklahoma City's anticipated development of additional water supply sources and continued investment in infrastructure (OCWUT, 2012).

3.1.3.3 Opinion of Costs

Most of the costs associated with continued use of wholesale treated water from Oklahoma City will come from the monthly or annual costs paid to Oklahoma City for water access and use. Capital costs for this source are limited to increasing supply capacity by constructing a second connection point. A second connection would include a limited length of water pipeline, flow meters, control valves, and an underground vault for housing equipment. This second connection would offer the ability to receive more water than currently available and offer a degree of redundancy when one of the connections is offline.

3.1.3.4 Summary of Individual Source

Table 3.7 summarizes information on purchasing treated water from Oklahoma City as a wholesale customer.

Table 3.7 Existing Water Supply Source – Purchase Treated Water from Oklahoma City (Wholesale)

Existing Yield Available to Norman	AFY	6,726
	mgd	6.0
Proposed Firm Yield Available to Norman(1)	AFY	13,451
	mgd	12
Percent of projected 2060 demands supplied by firm yield(2)	Percent	41
Raw Water Transmission Distance(4)	Miles	6
Water Treatment Process		N/A
Known Long-term Reliability Issues		
Known Implementation Issues		There are known permitting issues regarding use of water from Southeast Oklahoma (one of several sources used by Oklahoma City) that are currently unresolved.
Opinion of Capital Costs	2012 $	$14,100,000
Unit Capital Cost of Source(3)	$/AFY	$1,000

Notes:

(1) Proposed firm yield of 12 mgd used for preliminary screening.

(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).

(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.

(4) Assumed distance to connect Norman's distribution system to Oklahoma City's distance. When an exact connection location is determined, this distance should be revisited.

(5) Summed and converted values may vary slightly due to rounding.

3.2 NEW LOCAL SOURCES

Several new local supplies were considered for future water supply for Norman. These options include indirect potable reuse (using highly treated water from Norman's WRF for Lake Thunderbird augmentation or groundwater recharge), non-potable reuse, stormwater capture and reuse, diversions from the Canadian River, and capturing Lake Thunderbird spillage. This section describes these potential new local water sources.

3.2.1 Additional Water Conservation

This section describes Norman's current conservation measures and potential additional water use reductions through new programs.

3.2.1.1 <u>Description of Current Efforts</u>

Norman adopted its current Water Conservation Plan in 2014. The plan provides information on Norman's water system, current permanent conservation programs, and temporary demand reducing methods (such as even/odd watering restrictions) that are used during drought conditions. Norman implements several permanent conservation programs, some of which affect all users (like rate structures) while others are targeted to specific user categories.

Norman established an inclining block rate structure with base rate for residential customers in 2006. Under an inclining block rate structure, each "block" of water use above base monthly usage costs more on a thousand-gallons-used basis than the previous block of usage. Non-residential customers have a flat usage rate with base fee. Unlike other communities in Oklahoma, any change in Norman's water rates requires a majority vote of the public.

The City employs a "lead by example" approach for water conservation. For example, the City utilizes drip irrigation on medians and in other applicable areas to minimize overspray. In 2005, Norman passed an ordinance that requires installation of a rain sensor and freeze gauge on all new automatic irrigation systems. This promotes water conservation by shutting off irrigation systems when irrigation needs are low or zero. Additionally, Norman city codes require low flow fixtures in new construction (via Norman's adoption of the 1997 International Plumbing Code for non-residential construction and 1995 Council of American Building Officials for residential construction).

Norman meters all of its customers (including water used at City facilities) and periodically tests and replaces meters. In a recent testing/replacement program, Norman recognized a revenue increase due to more accurate water use measurements. Through leak detection training of meter readers, customer service, and public utilities staff, non-revenue water has been reduced to about 8 to 9 percent of total production.

Norman implemented design standards requiring strategically located isolation valves, in addition to a valve exercising and replacement program. Both of these activities reduce water lost to leaks. Building upon historical leak tracking, Norman has stopped using ductile iron pipe (prone to leaks due to soil corrosion) and executes a hot soil and urban pipe replacement program to prevent future water leaks.

During construction of new water transmission lines, Norman encourages efficient water use by limiting contractors on how much free water they can use for flushing of new mains; if additional flushes are required, contractors are charged for water used. Norman provides and requires the use of hydrant meters by contractors, and imposes fines for non-use. Farmers and smaller contractors have access to a coin-operated system for water truck filling.

Collectively, these current conservation programs have helped reduce the per capita water use. While exact water savings are difficult to determine, evidence of the community's response to Norman's conservation program can be seen in recent years' demand data as detailed in Chapter 2. Importantly, continuation of the existing programs (with continued savings at current levels) is reflected in the demand projections described in Chapter 2.

3.2.1.2 <u>Impacts of Expanded Conservation Programs</u>

To determine effects of expanding or adding new conservation programs, information developed as part of the OCWP was reviewed. Two conservation scenarios were studied. OCWP Scenario I evaluated moderately expanded conservation and represents programs that are most likely to be implemented based on cost and ease of implementation (OWRB, 2011). Water savings are included from passive conservation (those that will happen because of current state and federal plumbing codes that Norman has adopted), additional metering, conservation pricing (or increasing tiered rate structure), improved leak detection to decrease non-revenue water, and expanded education programs to decrease demand by 3 percent (OWRB, 2011). OCWP Scenario II evaluated substantially expanded conservation. Scenario II includes all programs from Scenario I plus additional improvements to achieve 100 percent metering, improved leak detection to further decrease non-revenue water, additional education to reduce demands by 5 percent, and implementation of higher-efficiency plumbing codes (OWRB, 2011).

The OCWP estimated conservation savings by county. In counties like Cleveland County, where Norman has already implemented portions of Scenarios I and II programs, projected reductions in demand only considered the programs not already in place in the county. This approach tailored the projected savings to each county, avoiding over-estimation of projected savings associated with implementation of Scenarios I or II.

For the 2060 SWSP, it was assumed that Norman will expand existing programs and/or implement new programs to achieve water reductions of 1.0 mgd by 2060 (i.e., a level between OCWP Scenario I and Scenario II). Table 3.8 summarizes conservation savings for Norman using OCWP data and estimates used in the 2060 SWSP.

Table 3.8 Conservation Savings for Norman (Post 2010)			
Year	Estimated Water Savings for Scenario I (mgd)(1)	Estimated Water Savings for Scenario II (mgd)(1)	Estimated Water Savings for 2060 SWSP (mgd)
2020	0.70	1.6	0.15
2030	0.74	1.9	0.36
2040	0.77	2.3	0.57
2050	0.79	2.5	0.78
2060	0.81	2.6	1.0

Notes:

(1) Norman's savings based on 60 percent of the 2012 Update to the OCWP estimates for Cleveland County, based on NUA's service area as a percent of total Cleveland County population that is served by a public water supply system.

3.2.1.3 Opinion of Costs

Conservation programs are not free, and may or may not be the most cost-effective "supply" depending on local conditions. The 2060 SWSP considered costs associated with additional conservation programs to be annual costs, rather than one-time capital costs. Evidence from Norman's existing programs, Norman's 2014 Water Conservation Plan, and communities throughout the country suggest that costs are generally associated with costs that are incurred annually. Examples include staff salaries, rebates for low-flow fixtures or appliances, and other annual costs driven by the level of implementation by members of the community.

3.2.1.4 Summary of Individual Source

Passive conservation (through low-flow fixture retrofits driven by plumbing code) is already integrated into the 2060 demand projections for NUA's service area. Because active conservation measures are only as effective as the degree to which they are adopted by the community, it is difficult to guarantee a specific level of conservation. Experience in states adjoining Oklahoma suggests that communities with no active conservation program can, in many cases, reasonably achieve a 10 percent reduction in demand through active conservation programs. With Norman's existing programs and successes in conservation, at least some of this 10 percent reduction has already been achieved. Thus, a lower value is recommended for purposes of long-range planning, until such time as the Conservation Plan is again updated.

The 2060 SWSP assumes a demand reduction of 1 mgd (annual average; peak day savings of 1.5 mgd) by 2060 through expansion of the City's existing water conservation programs. This corresponds to a savings of about 3 percent of total demand by 2060. To the degree that additional active conservation measures are adopted more rapidly by the community, demand projections can be revised accordingly. This may in turn allow for supply expansion projects to be delayed or deferred.

3.2.2 Additional Non-Potable Reuse

Non-potable reuse (NPR) uses highly treated water from a WRF to replace water used for irrigation (with or without restrictions depending on level of treatment) or some non-potable industrial uses. In 2012, the Oklahoma Department of Environmental Quality (ODEQ) finalized formal regulations for NPR in Oklahoma, governing the treatment, water quality, and application and management requirements specific to numerous types of NPR. NPR is already in place in Norman, with treated effluent from Norman's WRF used to irrigate the University of Oklahoma's golf course and with additional non-potable use at the WRF site itself.

3.2.2.1 Description of Supply Source

To support an analysis of potential candidates for conversion from potable supply to NPR, NUA provided a list of its top 200 highest water users and monthly water use amounts. The ratio of summer water use to winter water use was calculated for each of these users. Customers with high ratios were initially identified as potential candidates for non-potable irrigation reuse, and validated to confirm their likelihood of significant outdoor water use. Next, a list of potential industrial customers (those that could use non-potable water for cooling or other processes) was developed. These irrigation and industrial potential customer lists were combined with known future developments to create a comprehensive potential customer list showing location, along with average and peak day expected non-potable water use.

Potential customers located near the WRF were identified as conceptual candidates for a first-phase NPR expansion project. Sites closer to the WRF – the source of the water supply – can be served by reuse systems with less piping and pumping infrastructure and associated capital and operating costs.

The project proposes to serve approximately 21 customers using three main distribution pipelines. Phase I of the expanded NPR system, illustrated in Figure 3.3, would have an average day demand of 0.8 mgd and peak day demand 4.6 mgd. However, the piping associated with Phase I was sized for future flows (based on estimates of potential Phase II customers' needs that are located farther away from the WRF). Upgrades to the existing WRF would be needed, only for the portion of WRF that would be distributed to NPR customers on a peak day, in accordance with ODEQ regulations. Approximately 6.5 million gallons of system storage is proposed to reduce the WRF reuse treatment process capacity needed to approximately 2.7 mgd.

3.2.2.2 Challenges Associated with Non-Potable Reuse

NPR is gaining acceptance in the public and is increasingly an important component of how communities in Oklahoma efficiently meet their water demands. Because Norman already has an NPR program in place, many of the challenges have already been addressed. However, by implementing this supply option, the amount of flow discharged from the Norman WRF to the Canadian River would be reduced. The minimum amount of flow, if any, that would need to be discharged to the Canadian River may be subject to analyses by, and negotiation with, OWRB. In addition, future instream flow programs adopted and implemented in Oklahoma, if any, could affect the amount that would need to be discharged and thus affect the amount available for NPR. Overall, the amount of water that would be reused under this supply option is a small portion of the total effluent generated at the WRF, suggesting that this may not be a significant challenge for this supply option.

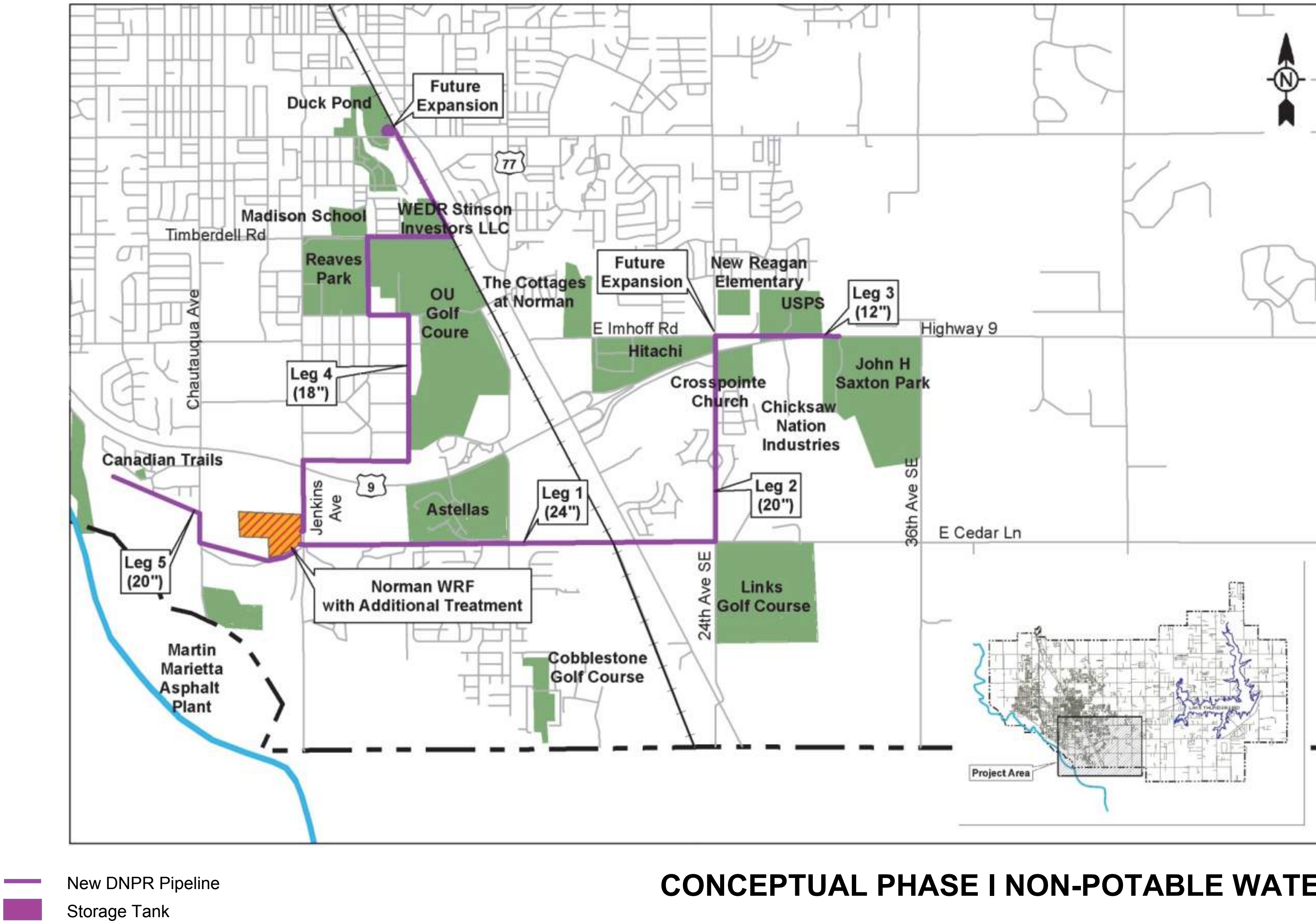
However, the availability of reclaimed water from the WRF is fairly certain. Even with continued/increased conservation, there will always be a relatively constant daily flow of wastewater treated at the Norman WRF. Evaluations of this source assumed that Phase I NPR expansion would occur in the southern and central portions of Norman delivered via conveyance infrastructure from the existing WRF on Norman's south side. However, if a North WRF were constructed, it would become more cost-effective to serve candidate NPR sites in the northern portion of the city as part of a Phase II expansion.

3.2.2.3 Opinion of Capital Cost

Capital costs associated with the upgrades and expansions at the WRF are associated with WRF process upgrades, based on improvements described in the Engineering Report Phase II Wastewater Treatment Plant Improvements (Norman, 2011). This report proposed using liquid sodium hypochlorite and filtration to meet ODEQ Category 2 reuse requirements. ODEQ's Category 2 allows essentially unrestricted use for turf irrigation. Costs were taken from this report and escalated to 2012 dollars then adjusted to reflect different treatment process sizing as described in Chapter 2. Approximately 6.5 million gallons of storage is incorporated in the system, which allows the treatment process train for the NPR portion of plant flows to be sized for 2.8 mgd instead of matching the peak NPR demand of 4.6 mgd. Additionally, pumping and new distribution piping are required for distributing water into the NPR system. Costs for those facilities were estimated for the Phase I NPR system expansion as part of the 2060 SWSP.

3.2.2.4 Summary of Supply Option

Table 3.9 summarizes information on expanded NPR using reclaimed water from the Norman WRF.



CONCEPTUAL PHASE I NON-POTABLE WATER REUSE

FIGURE 3.3

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

Table 3.9 New Local Water Supply Source – Non-potable Reuse		
Existing Demand Reduction Available to Norman	AFY	N/A
	mgd	N/A
Proposed Demand Reduction Available to Norman[1]	AFY	850
	mgd	0.8
Percent reduction in projected 2060 demands[2]	Percent	5
NPR Transmission Distance	Miles	8
Water Treatment Process[4]		Advanced wastewater treatment to meet ODEQ Category 2 reuse
Known Long-term Reliability Issues		WRF effluent is highly reliable
Known Implementation Issues		ODEQ rules are in place for non-potable reuse. Significant ability to control implementation locally. Potential requirements for continued discharges from WRF to Canadian River.
Opinion of Capital Costs	2012 $	$37,000,000
Unit Capital Cost of Source[3]	$/AFY	$22,000

Notes:

(1) Sized based on potential customers for Phase I NPR expansion project (0.8 mgd annual average) plus excess pipeline capacity for future customers (total 1.5 mgd annual average). Phase I peak day demand reduction is estimated at 4.6 mgd.

(2) Proposed demand reduction divided by Norman's projected 2060 demands (29.1 mgd).

(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.

(4) WRF upgrades assumed are described in the Engineering Report Phase II Wastewater Treatment Plant Improvements (Norman, 2011).

(5) Summed and converted values may vary slightly due to rounding.

3.2.3 Lake Thunderbird Augmentation (IPR)

This source evaluates augmenting, or supplementing, water supplies in Lake Thunderbird with highly treated water from Norman's WRF, with a primary goal of increasing the reliable yield from the lake. This is one type of indirect potable reuse (IPR), defined as potable reuse because it is used to augment potable water supply sources that are treated to drinking water standards, and designated as indirect reuse because it includes discharge to a water body where dilution and natural attenuation of certain parameters can occur before it is diverted from that water body for further treatment to potable standards.

In contrast, direct potable reuse would involve directly piping treated water from a WRF, with advanced treatment directly to the water treatment plant then into the potable distribution piping network. Direct potable reuse is not widely practiced in the U.S., but is being intensively researched with regard to treatment requirements, water quality requirements, process reliability, and public acceptability.

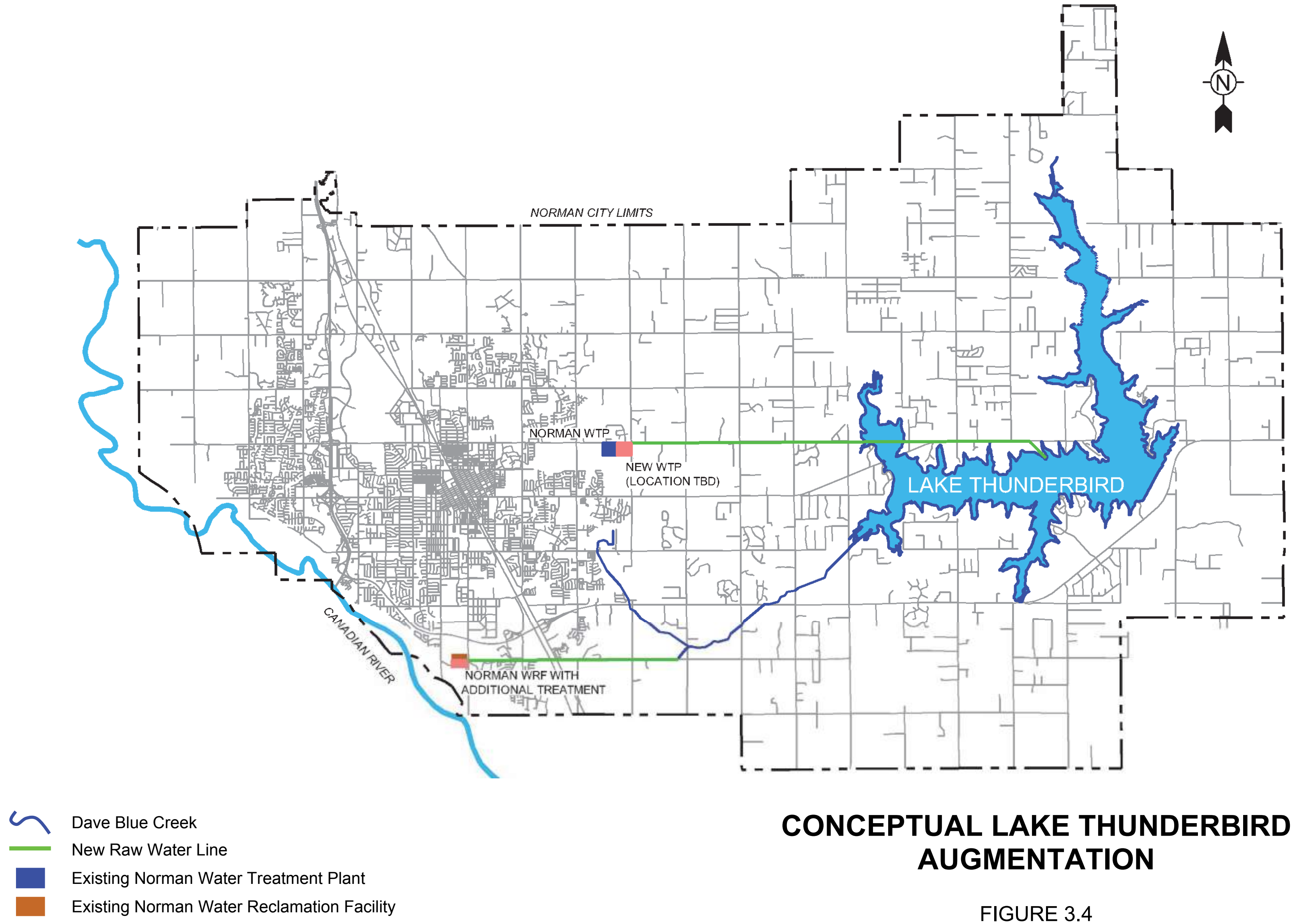
3.2.3.1 Description of Supply Source

The 2060 SWSP evaluation of Lake Thunderbird augmentation was based on a recent COMCD study that evaluated augmenting Lake Thunderbird using 15 mgd of reclaimed water from the City of Moore and/or Norman (COMCD, 2012). The COMCD study recommended augmenting Lake Thunderbird with 15 mgd of treated water from WRFs ((5 mgd from the Moore Wastewater Treatment Plant (WWTP) and 10 mgd from the Norman WRF)), phased in 5-mgd increments over the course of approximately 20 years. The COMCD study estimated that this augmentation would provide an additional yield of 15 mgd from Lake Thunderbird. The COMCD study did not estimate losses due to seepage and evaporation in Dave Blue Creek, which may lower the firm yield of this source for Norman slightly.

For the 2060 SWSP, analyses were based on augmenting Lake Thunderbird using only reclaimed water from the Norman WRF, as illustrated in Figure 3.4. Consistent with the COMCD study, it was assumed that the amount of water delivered to Lake Thunderbird would be available for raw water use (meaning seepage and evaporation losses were assumed to be negligible). It was assumed that augmentation with treated water from the WRF would be carefully managed to maximize the net additional yield from Lake Thunderbird.

Norman is projected to have wastewater flows totaling nearly 21 mgd by 2060 (Norman, 2011), with approximately 17 mgd in the southern collection basin (i.e., tributary to Norman’s existing WRF). For preliminary screening of supply sources, it was assumed that 15 mgd would be available to augment and then be recovered from Lake Thunderbird. However, for portfolio development (Chapter 4), other augmentation quantities may be used. More advanced treatment would be required at the Norman WRF to produce high quality water necessary for augmentation, particularly given the state’s designation of Lake Thunderbird as a SWS.

The COMCD study assumed WRF improvements including the conversion of the primary clarifiers to anaerobic zones, the construction of a new anoxic basin, the addition of new recycle pumps and piping for mixed liquor suspended solids (MLSS) between reactors, the addition of a centrifuge for waste activated sludge (WAS) thickening, the addition of diamond cloth filtration, the addition of a new chemical system, and other miscellaneous piping and pumps (COMCD, 2012). Endocrine disrupting compounds (EDCs) include a variety of compounds commonly present in municipal wastewater, and/or those that may pose a potential human health concern depending on their concentration levels and based on current toxicological understanding. While EDCs are not currently regulated at the state or federal level, the 2060 SWSP assumed additional treatment using biofiltration and ozone for the portion of WRF flow that would be reclaimed and sent to Lake Thunderbird. These assumptions were made to address concerns about the impacts of EDCs in reclaimed water used for potable supply augmentation, and to provide a conservatively high estimate of capital and operating costs for the Lake Thunderbird augmentation project.



CONCEPTUAL LAKE THUNDERBIRD AUGMENTATION

FIGURE 3.4

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

Treated water would be pumped approximately 4 miles from the Norman WRF to Dave Blue Creek, which feeds Lake Thunderbird by gravity (COMCD, 2012). Lake Thunderbird would serve as a terminal storage reservoir for the augmented supply. From Lake Thunderbird, water would be withdrawn using a new intake, then pumped through a new 42-inch, 15-mile long raw water pipeline parallel to the existing pipeline from Lake Thunderbird to an new WTP that uses conventional treatment with softening. To meet 2060 demands, the new WTP peak capacity would be sized at 28.5 mgd.

3.2.3.2 Challenges Associated with Lake Thunderbird Augmentation

There are several specific challenges associated with augmenting Lake Thunderbird.

- There are currently no state or federal regulations governing IPR, but ODEQ has been tasked by the legislature with developing rules for IPR.
- Lake Thunderbird is listed as a SWS, meaning that no discharges will be allowed that increase the load of any pollutant. ODEQ has not established protocol for evaluating or demonstrating compliance with this requirement, as further discussed in the COMCD Lake Thunderbird Augmentation study (COMCD, 2012). NUA staff has initiated discussions with ODEQ, OWRB, members of the legislature, and other regional partners in further defining how discharges could be implemented at Lake Thunderbird and other designated SWS water bodies.
- COMCD, who has responsibility for operating and maintaining facilities at Lake Thunderbird, is actively pursuing augmenting Lake Thunderbird (immediately using raw water purchased from Oklahoma City and long-term through IPR). An intergovernmental agreement with COMCD and the other two member cities would be necessary to use Lake Thunderbird as storage for reclaimed water. Among other things, it is anticipated that such an agreement would establish the terms of the supply augmentation (quantity and quality), the increased allocation of reservoir yield to Norman, and the methodology for allocating costs of maintaining and operating the reservoir in light of Norman’s increased use of the lake.
- Seepage and evaporation are concerns with discharging treated water from the WRF into Dave Blue Creek to transport it to Lake Thunderbird. Lake evaporation is a function of the surface area of the water stored in the lake at any given time, which may not be significantly increased with the proposed augmentation of supplies. The COMCD study did not account for these losses, and thus the additional yield will likely be some amount less than flow sent to the reservoir.
- By implementing this supply option, the amount of flow discharged from the Norman WRF to the Canadian River would be reduced. While there is some reuse in place in Oklahoma, there is no precedent in the state for redirecting a major proportion of existing WRF discharges for beneficial reuse. The minimum amount of flow, if any, that would need to be discharged to the Canadian River would be subject to analyses by, and negotiation with, OWRB. In addition, future instream flow programs adopted and implemented in Oklahoma, if any, could affect the amount that would need to be discharged and thus affect the amount available for Lake Thunderbird augmentation.

- Public outreach will be critical for gaining acceptance of IPR, particularly given the lack of IPR precedent in Oklahoma. Extensive research at the national level and experience in other states where IPR is increasingly common can be used as a guide for establishing treatment protocol, treated water quality standards, and securing public support.

These challenges collectively may affect the timing and amount of source development. However, if and when the source is developed, the availability of reclaimed water from the WRF is fairly certain. Even with continued/increased conservation, there will always be a relatively constant daily flow of wastewater treated at the Norman WRF. Evaluations of this source assumed that all augmentation of Lake Thunderbird would occur via pumped discharges from the existing WRF. However, if a North WRF is constructed in the future, discharges into the lake by gravity would be possible, reducing capital and operating costs slightly.

3.2.3.3 Opinion of Capital Cost

Capital costs would be associated with the upgrades at the WRF, a new WTP, and the transmission infrastructure to get water to and from Lake Thunderbird. Depending on the final contractual requirements, Norman's reservoir use and maintenance costs may increase for using additional storage in Lake Thunderbird, but these costs are unknown at this time and were not included in the 2060 SWSP.

3.2.3.4 Summary of Supply Option

Table 3.10 summarizes information on augmenting Lake Thunderbird with reclaimed water from the Norman WRF.

Table 3.10 New Local Water Supply Source – Lake Thunderbird Augmentation

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	16,809
	mgd	15
Percent of projected 2060 demands supplied by firm yield(2)	Percent	52
Raw Water Transmission Distance	Miles	11
Water Treatment Process(4)		WRF upgrades (biofiltration and ozone for lake augmentation flow) and WTP expansion (conventional with softening)

Table 3.10 New Local Water Supply Source – Lake Thunderbird Augmentation		
Known Long-term Reliability Issues		WRF effluent is highly reliable. Potential requirements for continued discharges from WRF to Canadian River could limit source availability.
Known Implementation Issues		Lack of IPR rules in Oklahoma, and designation of Lake Thunderbird as a SWS brings uncertainty in discharge water quality requirements. An agreement with COMCD and other member cities for discharges and additional storage and diversions may be necessary. Costs for increased use of the lake's capacity have not been established. Public outreach will be necessary to secure public acceptance.
Opinion of Capital Costs	2012 $	$138,000,000
Unit Capital Cost of Source(3)	$/AFY	$8,200

Notes:

(1) Proposed firm yield of 15 mgd used for preliminary screening, consistent with COMCD 2012 study. Higher or lower flow rates could be achieved, and source availability will grow over time as population increases result in additional flows at Norman's WRF.

(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).

(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.

(4) WRF upgrades assumed are described in the COMCD reuse study (COMCD, 2012).

(5) Summed and converted values may vary slightly due to rounding.

3.2.4 Stormwater Capture and Reuse

Stormwater capture and reuse would capture and divert urban stormwater runoff to beneficial reuse, instead of historical practices of conveying the stormwater flow to receiving water bodies such as streams, lakes, and rivers.

3.2.4.1 Description of Supply Source

For the 2060 SWSP, stormwater reuse was analyzed by assessing a system where it would be captured and conveyed through a network of pipes to a new terminal storage reservoir. With treatment, it could be used as a water supply source. Four drainage basins that currently discharge stormwater to the Canadian River were identified as potential sources for new raw water supply, as shown in Appendix I. These basins are relatively close to the Norman WTP, and existing stormwater collection infrastructure transports runoff to a central location. The 2060 SWSP project would collect water at these centralized locations and transport it for treatment as illustrated in Figure 3.5. Runoff in basins naturally tributary to Lake Thunderbird were not considered for capture and reuse, as that would reduce the available supply from the lake.

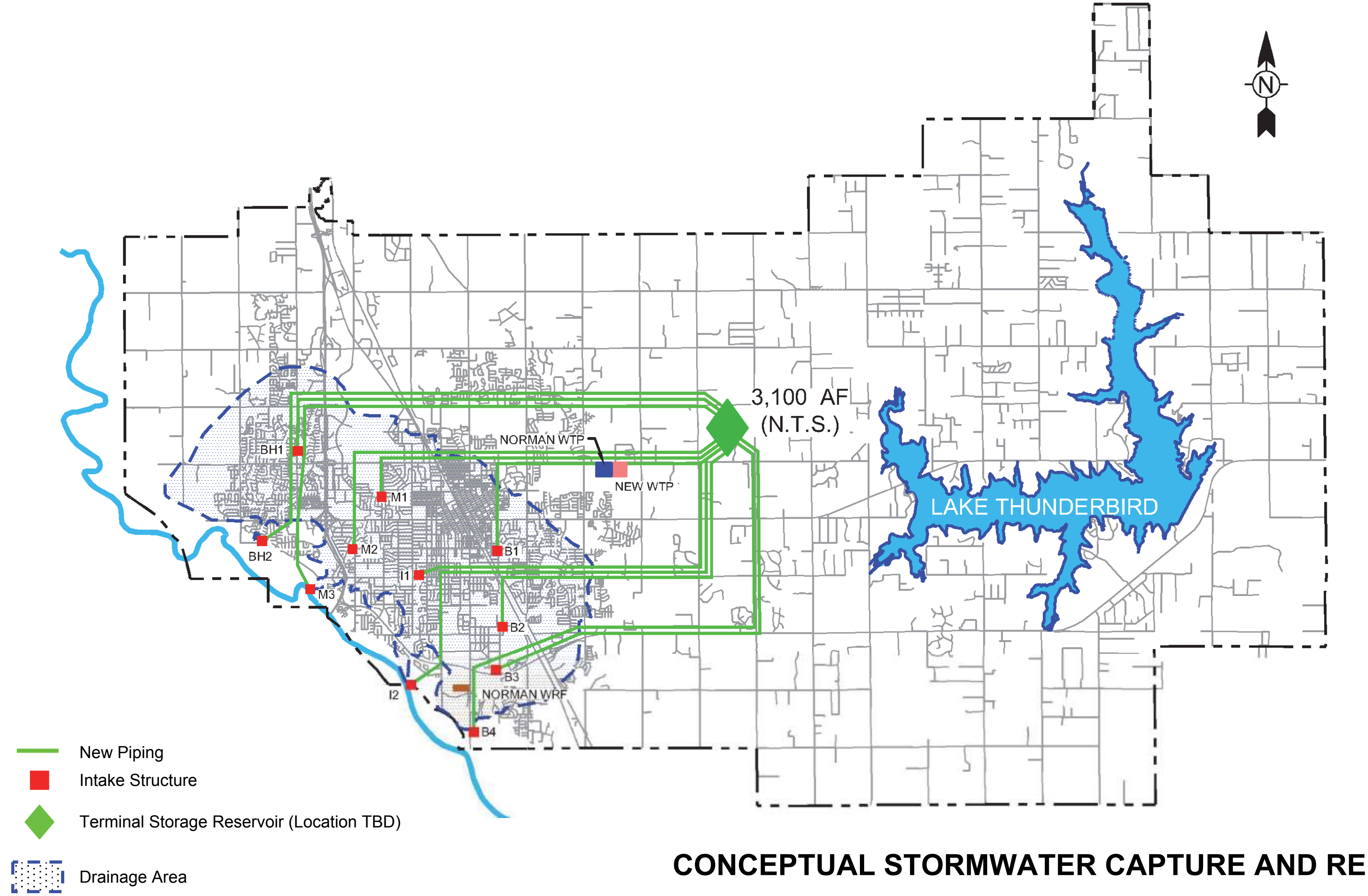
Collection and transmission infrastructure sizing was based on the annual stormwater runoff available in each basin and a maximum hourly diversion based on a precipitation rate of 1.5 inch per hour. Precipitation rates above this would not be captured by the system for beneficial reuse. As rainfall frequently comes in large quantities over a short period of time, collection and conveyance infrastructure is quite large, with pipeline diameters ranging from 108 inches to 132 inches in diameter and an average intake structure size of 300 mgd. Because stormwater is an intermittent water source, terminal storage is required to make this supply option reliable. Without storage, this source would only be available for short periods of time at very high flow rates, and alternate sources would be needed to supplement times between storm events.

It was important to find a balance between available supply and infrastructure costs, considering the infrastructure needed to capture, convey, and store the available runoff. Firm yield was determined by optimizing the unit costs for this supply without allowing the stormwater yield to drop below 20 percent of Norman's projected 2060 water demand. This resulted in a firm yield of 5.8 mgd and a terminal storage reservoir with 3,100 AF of storage, based on stormwater diversions of 1,800 AF per month. More information on this source is available in Appendix I. Terminal storage siting was not analyzed as part of the SWSP, but conveyance infrastructure costing analyses assumed that it would be located within Norman city limits.

It is difficult to anticipate exact water treatment requirements for stormwater collection because the stormwater can collect a variety of contaminants through overland flow, particularly in urban environments. For the 2060 SWSP, it was estimated that the treatment requirements for this water supply option would be a blend of conventional treatment and reverse osmosis treatment to meet potable standards. Non-potable use of this supply was not evaluated, in light of water quality variability that cannot be controlled or predicted and a lack of significant non-potable demand in winter months, which would in turn under-utilize the available resource.

3.2.4.2 Challenges Associated with Stormwater Capture and Reuse

Similar to both IPR and NPR, this supply source would reduce the amount of water that flows to the Canadian River. An assessment of potential impacts on downstream water users' supplies, in direct consultation with OWRB, would be required prior to implementing this option. Any future instream flow program requirements, if adopted in Oklahoma, could also affect the implementation of this supply option.



CONCEPTUAL STORMWATER CAPTURE AND REUSE

FIGURE 3.5

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

3.2.4.3 Opinion of Capital Cost

Capital costs were calculated, using assumptions described in Chapter 2, for transmission piping, pumping, terminal storage, and treatment associated with the capture, transport, and treatment of stormwater.

3.2.4.4 Summary of Supply Option

Table 3.11 summarizes information on the Stormwater Capture and Reuse option.

Table 3.11 New Local Water Supply Source – Stormwater Capture and Reuse

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	6,500
	mgd	5.8
Percent of proposed firm yield in projected 2060 demands(2)	Percent	20
Raw Water Transmission Distance	Miles	96
Water Treatment Process		Blend of conventional and reverse osmosis (at new WTP)
Known Long-term Reliability Issues		Reliability is function of terminal storage and variability in local precipitation
Known Implementation Issues		Requires significant study of feasibility. Significant land needed in developed areas for transmission and terminal storage.
Opinion of Capital Costs	2012 $	$1,220,000,000
Unit Capital Cost of Source(3)	$/AFY	$190,000

Notes:
(1) Size constrained based on size and cost of infrastructure required. Additional yield is possible with increased sizing of infrastructure.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.

3.2.5 Canadian River Diversion

The Canadian River runs along the southwest border of Norman, and a significant portion of this water remains unpermitted and available for use as a water supply source.

3.2.5.1 Description of Supply Source

Developing the Canadian River as a source of water supply for Norman would require obtaining permits from the OWRB; construction of a diversion and intake system; permitting, land acquisition, and construction of a new terminal storage reservoir; construction of a new WTP or an expansion of the existing Vernon Campbell WTP; and construction of conveyance infrastructure from the intake system to the terminal storage reservoir and from the terminal storage reservoir to the WTP.

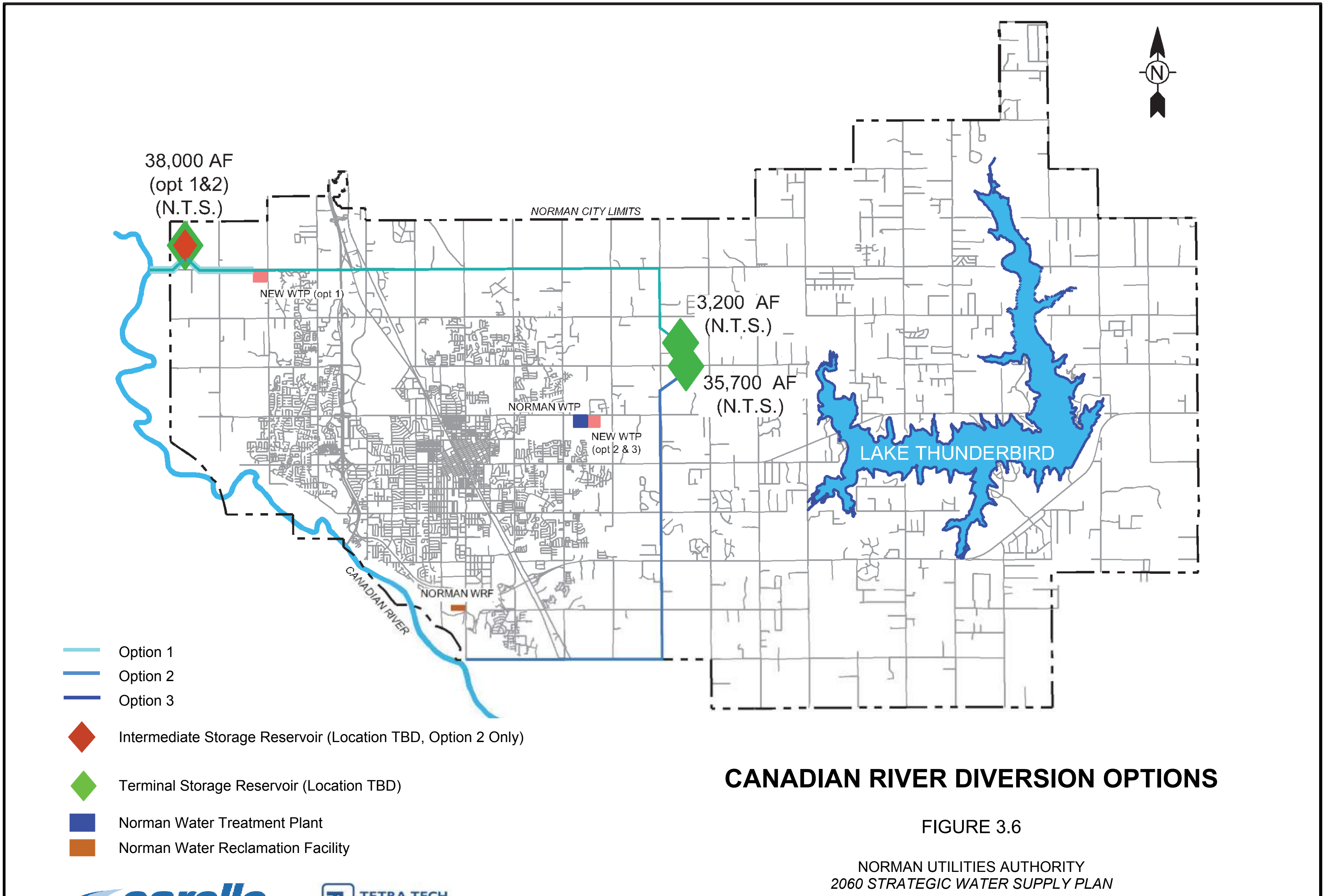
Diversion infrastructure and terminal storage sizing was based on monthly mean flow rates from the Canadian River at Bridgeport USGS Streamflow Gage ID# 07228500, 1970-2011 (USGS, 2011). Water supply diversions were assumed to be taken only when the flow rate in the Canadian River exceeded 100 cubic feet per second (CFS, equal to 155 mgd). Similar to Stormwater Capture and Reuse, a balance between size and cost of infrastructure and firm yield must be reached.

As with the stormwater capture supply option, the variability of flows in the river results in a need for terminal storage of diverted supplies in order to make the source consistently available to NUA's customers. Again, terminal storage siting was not analyzed as part of the SWSP, but conveyance infrastructure costing analyses assumed that it would be located within Norman city limits.

Three Canadian River diversion options initially were evaluated and are shown in Figure 3.6:

- Option 1 involves a 6.0-mgd diversion (maximum diversion of 2,000 acre-feet per month or AFM) from the Canadian River, a 38,000 AF terminal storage near the diversion point, and a new WTP all located on the northwest side of Norman.
- Option 2 involves a 6.0-mgd diversion (maximum diversion of 2,000 AFM) from the Canadian River and an intermediate 34,800 AF storage reservoir on the northwest side of Norman and a 3,200 AF terminal storage reservoir and expansion of the existing Norman WTP (both on east side of the city).
- Option 3 has a 6.0-mgd diversion (maximum diversion of 1,830 AFM) from the Canadian River on the southeast side of Norman and a 35,700 AF terminal storage reservoir and expansion of the existing Norman WTP. Because this diversion point is downstream of the discharge from the Norman WRF (which is very reliable), this option allows for the same firm yield with slightly smaller infrastructure.

Of the three options considered for Canadian River diversions, Option 1 has the shortest raw water transmission distance and allows the treated water to enter the distribution system at a strategic location on the northwest side. This point of entry into the distribution system would help meet demand and pressure requirements in northwest Norman.



CANADIAN RIVER DIVERSION OPTIONS

FIGURE 3.6

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

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Option 3 was determined to be less feasible and cost-effective than IPR via augmentation of Lake Thunderbird with WRF effluent, and was thus not considered further. Issues affecting its feasibility, relative to Lake Thunderbird augmentation, include: the need for significant diversion infrastructure from the river; the salinity of both the WRF effluent and Canadian River supplies which when blended would likely require advanced treatment (e.g., reverse osmosis) for potable use, which would not be needed with augmented Lake Thunderbird supplies; and the need for terminal storage to buffer supply availability against seasonal demands, which is already constructed and available for the Lake Thunderbird augmentation IPR option.

Option 1 was selected as the basis of evaluation for this supply source. More information on all three Canadian River diversion options is available in Appendix J. The anticipated treatment required for the Canadian River diversions is a blend of conventional water treatment plus reverse osmosis to reduce the high concentrations of total dissolved solids in the river to below the EPA's secondary MCL of 500 mg/L.

The feasibility of using a series of low-head dams near Norman on the Canadian River as a water supply source was also considered. An evaluation of river flows and storage yields indicated that use of low-head dams would provide very limited firm yield (less than 0.5 mgd) and would require a large terminal storage reservoir to improve the firm yield. Achieving a similar yield with this option would be more expensive than other Canadian River sources and it was therefore not considered further.

3.2.5.2 Challenges Associated with Canadian River Diversion

A water rights permit must be obtained through the OWRB to withdraw water from the Canadian River. The OCWP Central Watershed Planning Region Report (OWRB, 2012) indicates that this reach of the Canadian River, in OCWP Basin 58, does have availability for additional permits. Additional challenges include water quality and supply variability issues, as described earlier in this section.

3.2.5.3 Opinion of Capital Cost

Capital costs were calculated, using assumptions described in Chapter 2, for transmission piping, pumping, terminal storage, and treatment associated with the diversion, transport, storage, and treatment of Canadian River water.

3.2.5.4 Summary of Supply Option

Table 3.12 summarizes information on the Canadian River Diversion option.

Table 3.12 New Local Water Supply Source – Canadian River Diversion (Option 1)		
Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	6,700
	mgd	6.0
Percent of proposed firm yield in projected 2060 demands(2)	Percent	21
Raw Water Transmission Distance	Miles	1
Water Treatment Process		Blend of conventional and reverse osmosis (at new WTP)
Known Long-term Reliability Issues		OCWP Basin 58 (where diversion would be located) is shown to have some shortages in OCWP 2060 projections. Reliability for proposed project is a function of terminal storage and precipitation patterns.
Known Implementation Issues		Requires significant study of feasibility. Significant land needed for terminal storage.
Opinion of Capital Costs	2012 $	$264,000,000
Unit Capital Cost of Source(3)	$/AFY	$39,000

Notes:
(1) Yield constrained based on size and cost of infrastructure required. Slight increase in yield is possible if diversion is located downstream of Norman WRF.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.

3.2.6 Lake Thunderbird Spillage

Lake Thunderbird's primary purpose is for municipal and industrial water supply with secondary uses for flood control, recreation and fish and wildlife propagation. Under the flood control intended use, water must be released from Lake Thunderbird in order to maintain the designated flood pool elevations. The Lake Thunderbird Spillage water supply option considers collecting this water for use.

3.2.6.1 Description of Supply Source

Historical records of monthly releases from Lake Thunderbird were reviewed to determine how much water could potentially be captured. The quantity of water released from Lake

Thunderbird is inconsistent and can be infrequent. Historical data show that it is common for there to be no releases from Lake Thunderbird for consecutive years (as seen in water years of 2011 and 2012). However, when water is released, it is released in large quantities over a short period of time. Due to the infrequent nature of this supply source, terminal storage is required in order to develop a firm yield that can be relied upon.

Similar to the Stormwater Capture and Canadian River Diversion options, a balance between size and cost of infrastructure and firm yield was sought. For purposes of preliminary screening, the firm yield was set to a minimum of 5.8 mgd, equal to 20 percent of Norman’s projected 2060 demands.

Historically, the U.S. Army Corps of Engineers (USACE) calls for releases from the lake in order to evacuate the flood pool as quickly as practical. Permitting of the flood pool is uncertain (OWRB and federal agencies in Oklahoma have not previously issued permits for withdrawal of flood pool supplies). Should it be permitted, it is likely that the withdrawal of water from the flood pool would need to occur at the same high rate that water would typically be released (i.e., the flood pool cannot be used to store water). Releases from the flood pool downstream could be conducted in conjunction with diversions directly from the flood pool for water supply, provided the combined total met USACE’s goals for timely evacuation of the flood pool storage volume.

Two options for capturing spillage initially were evaluated:

- Option 1 involves collecting water from the flood pool in Lake Thunderbird before it is released.
- Option 2 would collect water just downstream of Lake Thunderbird (after it has been released from the flood pool).

Both options require permits from OWRB for surface water diversions, and both would require substantial infrastructure to collect the large volumes of water quickly. Option 1 would require less conveyance infrastructure and was thus selected for analysis. The Capture Lake Thunderbird Spillage project is illustrated in Figure 3.7.

Sizing of infrastructure (intake, pumping, transmission pipelines), was based on an average monthly releases occurring over half the days in a month, resulting in spillage capture infrastructure sized to handle a peak flow of approximately 100 mgd. A terminal storage reservoir of 75,000 AF would be required to meet the desired yield. The large amount of terminal storage is driven by the highly infrequent and variable availability of water in the flood pool. With consecutive years of no spillage supply availability, terminal storage would need to hold enough water to supply an annual and peak-season demand reliably. To provide a sense of the magnitude of the required terminal storage reservoir, Lake Thunderbird has normal pool storage of just over 100,000 AF. The existing Norman WTP (conventional with softening) would be expanded by approximately 11 mgd to treat the water captured.

3.2.6.2 Challenges Associated with Lake Thunderbird Spillage

Regulatory impacts are fairly minimal for this water supply. Approval would be required through the OWRB and the Bureau of Reclamation, both of whom appear open to the concept (OWRB, 2012). Their primary concern would be any downstream water users that may be impacted by less water in the river as a result of this water supply option.

3.2.6.3 Opinion of Capital Cost

Capital costs were calculated, using assumptions described in Chapter 2, for collection, conveyance, terminal storage, and treatment associated with using water from the Lake Thunderbird flood pool.

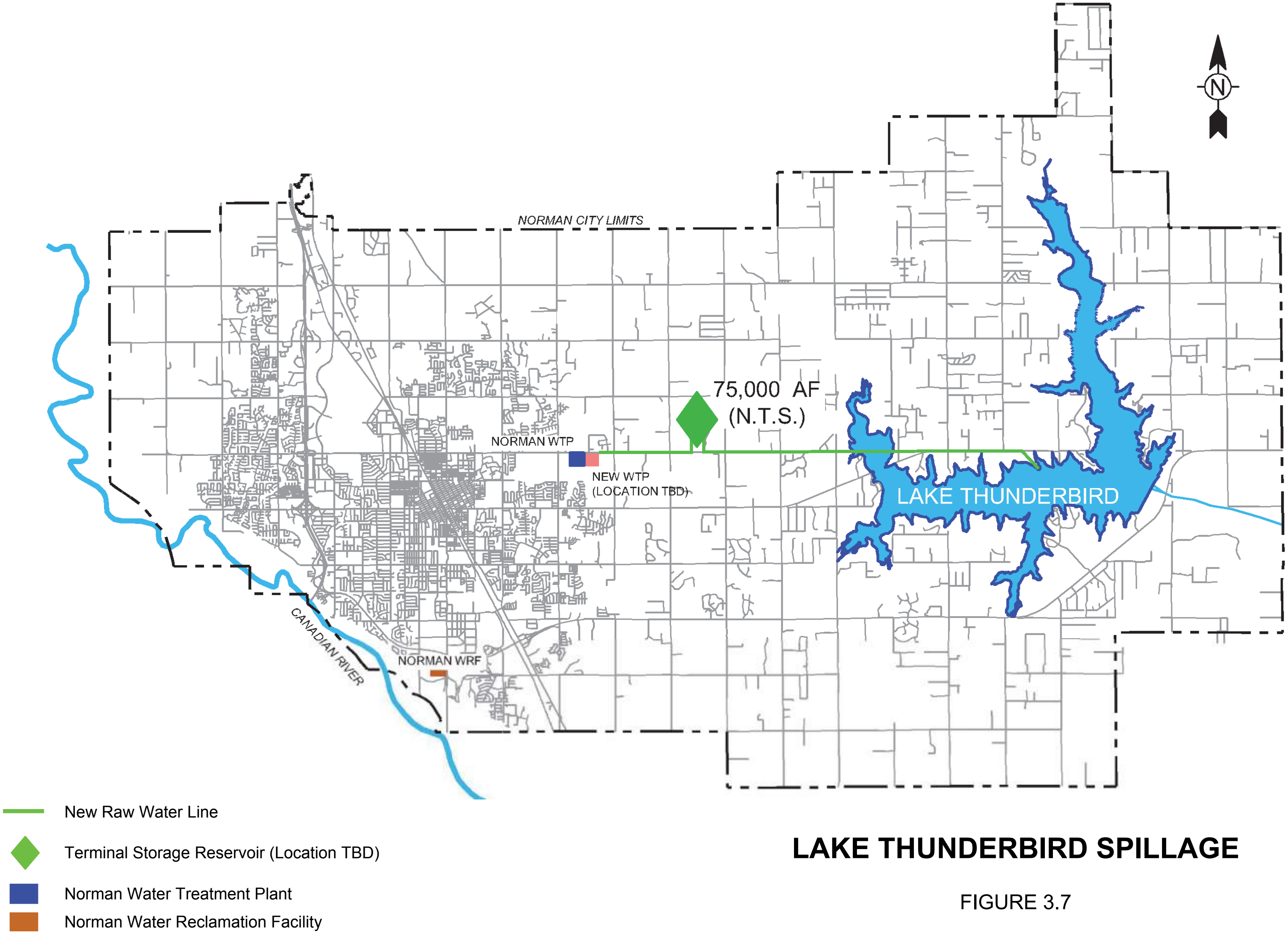
3.2.6.4 Summary of Supply Option

Table 3.13 summarizes information on the option to capture Lake Thunderbird Spillage.

Table 3.13 New Local Water Supply Source – Lake Thunderbird Spillage

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	6,500
	mgd	5.8
Percent of proposed firm yield in projected 2060 demands(2)	Percent	20
Raw Water Transmission Distance	Miles	7
Water Treatment Process		Conventional with softening
Known Long-term Reliability Issues		Reliability is a function of terminal storage.
Known Implementation Issues		Source has not been studied or permitted. OWRB will have to confirm than no downstream water rights holders will be impacted. Concurrence and approval from BOR and USACE would be needed. Significant land acquisition required for terminal storage.
Opinion of Capital Costs	2012 $	$510,000,000
Unit Capital Cost of Source(3)	$/AFY	$79,000

Notes:
(1) Yield constrained based on size and cost of infrastructure required.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.



LAKE THUNDERBIRD SPILLAGE

FIGURE 3.7

NORMAN UTILITIES AUTHORITY

2060 STRATEGIC WATER SUPPLY PLAN

3.2.7 Groundwater Recharge (IPR)

Another option for reusing water from the Norman WRF is groundwater recharge. This water supply option involves injecting highly treated water from the Norman WRF into the Garber-Wellington Aquifer for storage and future recovery.

3.2.7.1 Description of Supply Source

In the absence of a detailed hydrogeological study and precedence for groundwater recharge in Oklahoma, several assumptions were made to develop this water supply project, as summarized below:

- Recharge will occur through injection wells. Given that Garber-Wellington Aquifer levels are approximately 650 feet below the ground surface and that the types of soils prevalent in the area are not conducive to rapid percolation, surface recharge is not preferred.
- Based on aquifer recharge injection well projects in other states, the average injection rate was assumed to be approximately 100 gallons per minute (gpm), or approximately 60 percent of the average withdrawal rate from existing Garber-Wellington Aquifer wells of 170 gpm.
- Water from the Norman WRF will require reverse osmosis and ultra-violet (UV) disinfection prior to injection into the Garber-Wellington Aquifer, in order to meet undefined but anticipated stringent water quality requirements.
- Upon withdrawal, reclaimed water will require wellhead chlorination prior to going into the potable distribution system. It is unknown whether arsenic and/or chromium-6 treatment will be required for reclaimed water. For purposes of preliminary screening, costs for arsenic and chromium-6 treatment were not included.

In lieu of physical demonstrations, modeling, or permitting precedent, it was conservatively assumed that 60 percent of water recharged could be physically and legally recovered. The Groundwater Recharge supply has a firm yield of 10.2 mgd, based on treating and injecting 17 mgd reclaimed water from the Norman WRF. It was assumed that water from the WRF designated for recharge would need to be recharged into the aquifer for blending and natural attenuation before it could be used as potable water. Therefore, a separate non-potable distribution piping network is required to convey water from the WRF to a network of dedicated injection wells.

Approximately 120 new injection wells and 28 new withdrawal wells are needed to achieve this firm yield. Injection wells, similar to withdrawal wells, must be spread out across the city to avoid interference between wells. The conceptual design for this water supply is illustrated in Figure 3.8.

3.2.7.2 Challenges Associated with Groundwater Recharge

Oklahoma does not have any regulations or applications of groundwater recharge using water from a WRF. It is anticipated that if such recharge were to be approved, ODEQ would require extremely stringent water quality and reliability standards for treatment and monitoring. From a physical water supply and permitting perspective, advanced modeling may be required to demonstrate the degree to which injected water could be recovered by withdrawal wells. Implementation of groundwater recharge will require significant study to confirm recovery rates and recharge's impact on constituent mobilization as well as significant regulatory negotiation.

3.2.7.3 Opinion of Capital Cost

Capital costs were calculated, using assumptions described in Chapter 2, for collection, conveyance, treatment, distribution to and injection wells, and withdrawal prior to entering the potable distribution system associated with groundwater recharge.

3.2.7.4 Summary of Supply Option

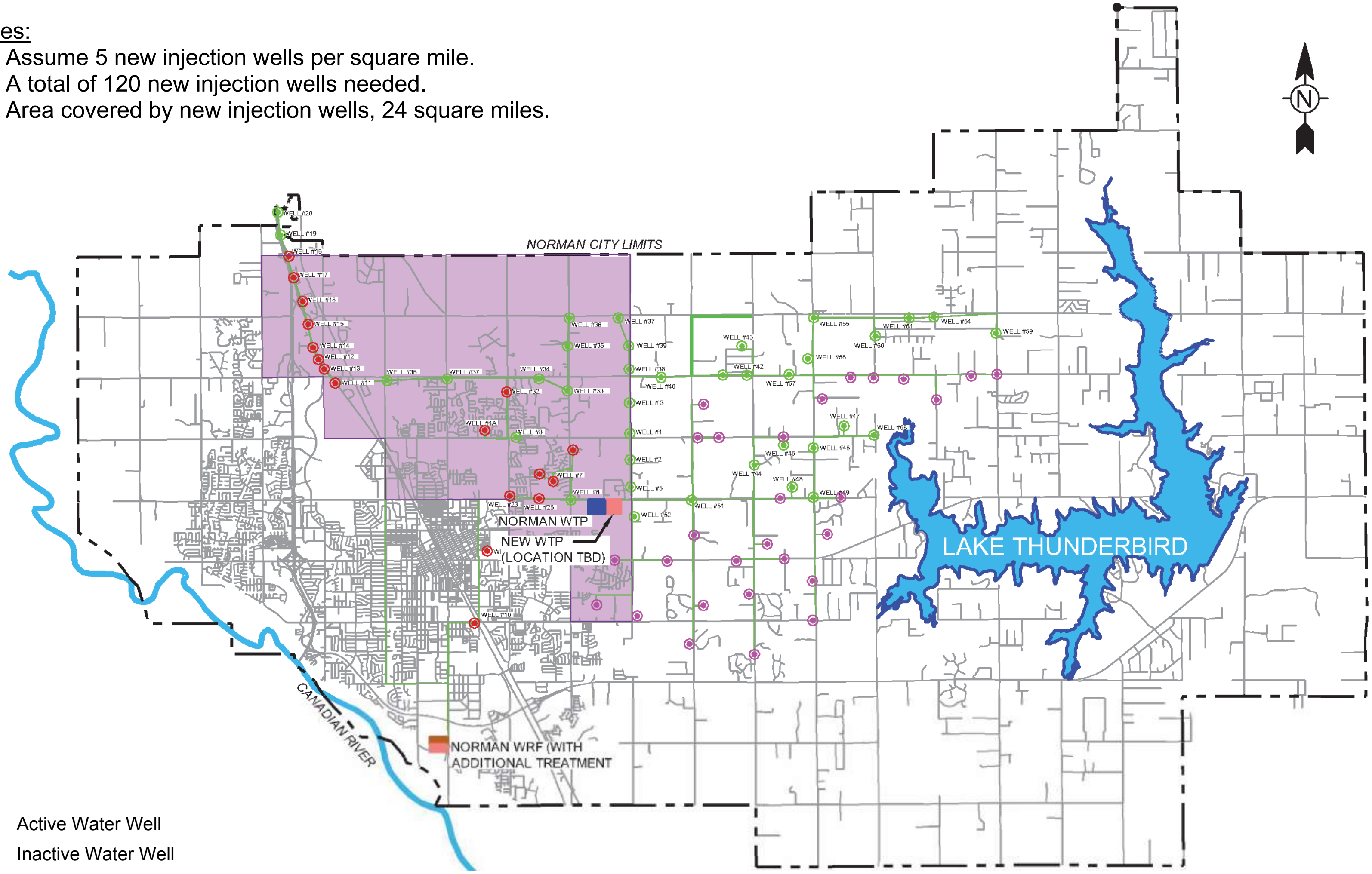
Table 3.14 summarizes information on the Groundwater Recharge supply source.

Table 3.14 New Local Water Supply Source – Groundwater Recharge

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	11,400
	mgd	10.2
Percent of proposed firm yield in projected 2060 demands(2)	Percent	35
Raw Water Transmission Distance(5)	Miles	89
Water Treatment Process(6)		Single pass reverse osmosis with UV disinfection
Known Long-term Reliability Issues		WRF effluent is highly reliable
Known Implementation Issues		Lack of permitting precedent or regulations for water quality and quantity. Subsequent study is needed to confirm recharge rates. Significant number of new well sites are required, with associated land acquisition needs.
Opinion of Capital Costs	2012 $	$364,000,000
Unit Capital Cost of Source(3)	$/AFY	$32,000

Notes:
(1) Yield constrained based on size and cost of infrastructure required.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.
(5) Transmission distance includes pipelines out to injection wells and pipelines from new withdrawal wells.
(6) Treatment listed is required prior to groundwater injection. Chlorine disinfection is assumed upon groundwater withdrawal.

Notes:
- Assume 5 new injection wells per square mile.
- A total of 120 new injection wells needed.
- Area covered by new injection wells, 24 square miles.



- Active Water Well
- Inactive Water Well
- New Water Well
- New Raw Water Line
- Injection Water Well Area (assumes 5 injection wells per square mile)
- Norman Water Treatment Plant
- Norman Water Reclamation Facility

CONCEPTUAL GROUNDWATER RECHARGE

FIGURE 3.8

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

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3.3 NEW REGIONAL SOURCES

This section discusses potential new regional supplies to meet Norman's future needs.

3.3.1 Co-owner with Oklahoma City for Southeast Oklahoma Treated Water

In this supply option, Norman would partner with Oklahoma City (as co-owners in infrastructure and supply) for a new regional raw water supply and subsequent treatment.

3.3.1.1 Description of Supply Source

This water supply option is generally based on Theme D1 from the Regional Raw Water Supply Study (OCWUT, 2009) and is illustrated in Figure 3.9. Oklahoma City, Norman, and several other water suppliers participated in this regional study, however it is unknown which, if any, study participants will ultimately take part in the capital project. Raw water would be diverted from one of several Southeast Oklahoma surface water diversion points considered in the study, then conveyed to one of Oklahoma City's existing supply sources (Lake Atoka and/or McGee Creek Reservoir). A transmission system parallel to the existing Atoka pipeline would bring water to Oklahoma City's Lake Stanley Draper for regional treatment at an expanded Draper WTP (one of Oklahoma City's existing WTPs), then conveyed to Norman through an interconnection between Oklahoma City and Norman's potable water distribution systems.

This project is expected to be implemented by Oklahoma City in phases, with the Atoka parallel pipeline being constructed and operated for several years before a new line from a diversion point in the Kiamichi River basin is needed to augment supplies, Norman's pro-rata costs for both project phases were included in 2060 SWSP analyses of this supply option. SWSP analyses of this option assumed that Norman would participate as a co-owner in the supply infrastructure, where Norman would provide its pro-rata share of capital costs and operating costs rather than purchasing water from Oklahoma City on a wholesale basis.

Norman's costs for participation were adjusted to reflect an increase in Norman's portion of supply relative to that assumed in the 2009 study. No new terminal storage reservoir is required, as Lake Stanley Draper will serve as terminal storage.

3.3.1.2 Challenges Associated with Co-owner with Oklahoma City for Southeast Oklahoma Treated Water

This water supply option is not without uncertainties, as water rights are currently under dispute between Oklahoma City, the State of Oklahoma, and Native American Tribes. Moreover, permitting for a project of this magnitude (independent of water rights issues) can be difficult and require lengthy analyses.

Since the 2009 study, however, Oklahoma City has continued to pursue planning and preliminary engineering for the Atoka parallel pipeline and Kiamichi basin diversion. The parallel conveyance system is currently in preliminary design. Those efforts, coupled with revisions to participation levels by metro area communities, may result in changes to the pipeline and booster pump station sizing and costing from what was presented in the 2009 study.

3.3.1.3 Opinion of Capital Cost

Capital costs for the project were adjusted from the 2009 study to reflect 2012 dollars and an pro-rata increase in Norman's portion of the project's supply. Other costs were based on unit costs described in Chapter 2.

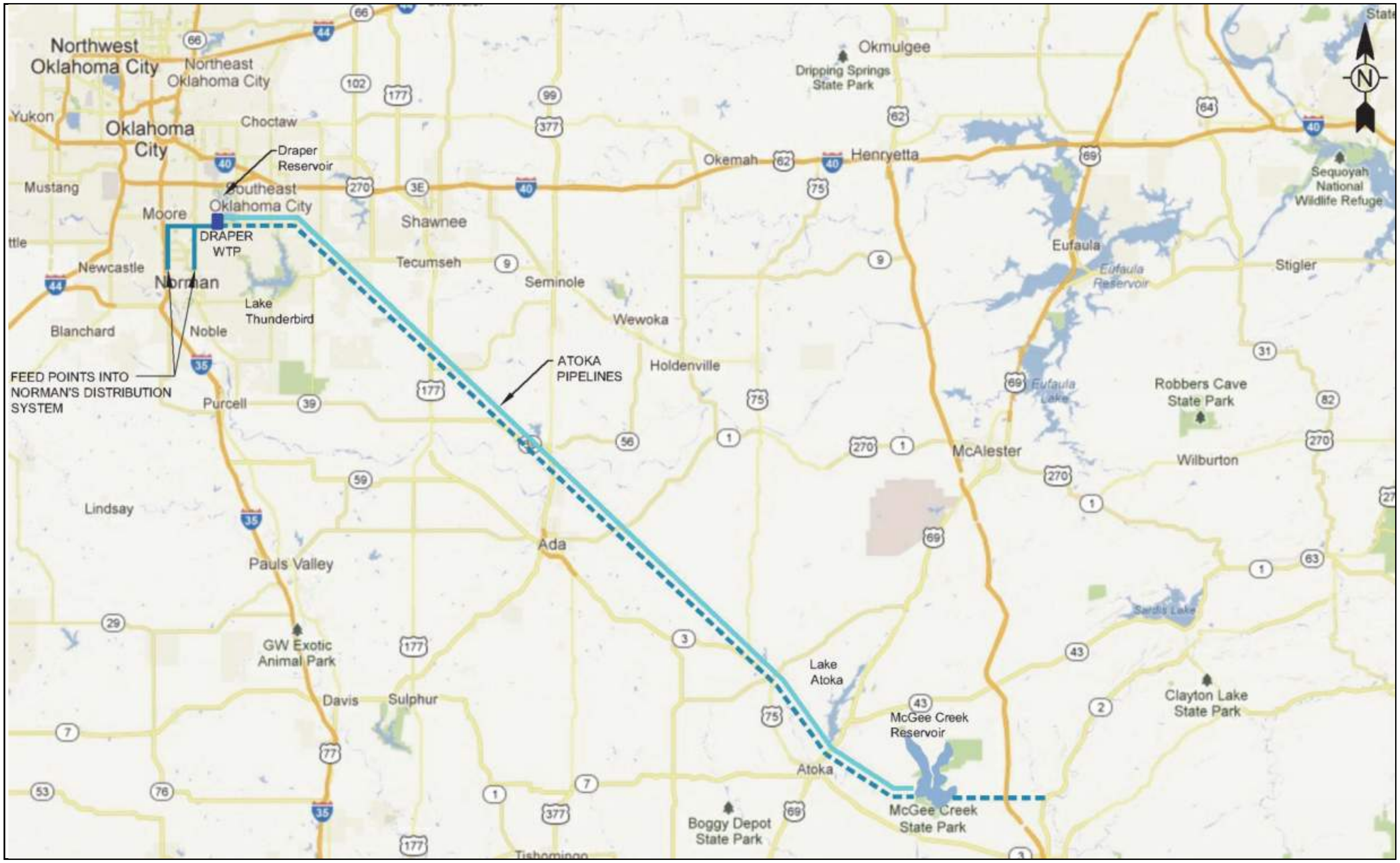
3.3.1.4 Summary of Supply Option

Table 3.15 summarizes information on the Co-owner with Oklahoma City for Treated Water supply source.

Table 3.15 New Regional Water Supply Source – Co-owner with Oklahoma City for Southeast Oklahoma Treated Water

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman[1]	AFY	32,600
	mgd	29.1
Percent of proposed firm yield in projected 2060 demands[2]	Percent	100
Raw Water Transmission Distance	Miles	133
Water Treatment Process		Conventional
Known Long-term Reliability Issues		Source reservoirs are constructed. From 2012 Update to OCWP, source basin is not shown to have any shortages through 2060.
Known Implementation Issues		There are known water rights issues that must be resolved. The source project is actively being pursued by Oklahoma City.
Opinion of Capital Costs	2012 $	$407,000,000
Unit Capital Cost of Source[3]	$/AFY	$12,000

Notes:
(1) Pending negotiations with Oklahoma City, yield could be any amount. For source evaluation, a yield equal to Norman's full projected 2060 demand was used.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.



New Treated Water Line
Existing Treated Water Line
Existing Shared Water Line
Draper Water Treatment Plant

CONCEPTUAL CO-OWNER WITH OKLAHOMA CITY FOR SOUTHEAST OKLAHOMA TREATED WATER

FIGURE 3.9

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

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3.3.2 Co-owner with Oklahoma City for Southeast Oklahoma Raw Water

In this supply option, Norman would partner with Oklahoma City (as co-owners in infrastructure and supply) for a new regional raw water supply. In contrast to the previous supply option, treatment remains wholly Norman's responsibility. Norman would receive untreated (raw) water from a joint project with Oklahoma City, then treat Norman's portion of the water at a new or expanded Norman WTP.

3.3.2.1 Description of Supply Source

This water supply option is generally based on Theme D3 from the Regional Raw Water Supply Study (OCWUT, 2009) and is illustrated in Figure 3.10. Oklahoma City, Norman, and several other water suppliers participated in this regional study; however, it is unknown which, if any, study participants will ultimately take part in the capital project. Raw water would be diverted from one of several Southeast Oklahoma surface water diversion points considered in the study, then conveyed to one of Oklahoma City's existing supply sources (Lake Atoka and/or McGee Creek Reservoir). A transmission system parallel to the existing Atoka pipeline would bring water to Central Oklahoma for subsequent treatment by individual participants. Norman's costs for participation were adjusted to reflect an increase in Norman's portion of supply relative to the 2009 study. Additionally, a 15-mile, 36-inch pipeline is dedicated for bringing water from the Atoka pipeline to Norman is included.

This project is expected to be implemented by Oklahoma City in phases, with the Atoka parallel pipeline being constructed and operated for several years before a new line from a diversion point in the Kiamichi River basin is needed to augment supplies, Norman's pro-rata costs for both project phases were included in 2060 SWSP analyses of this supply option. SWSP analyses of this option assumed that Norman would participate as a co-owner in the supply infrastructure, where Norman would provide its pro-rata share of capital costs and operating costs rather than purchasing water from Oklahoma City on a wholesale basis.

Because raw water would be delivered directly to Norman, a new terminal storage reservoir would be required to buffer steady raw water deliveries against variable treated water demands. The terminal storage reservoir would be placed into service when Norman's peak day needs from this supply source exceed the 2060 average day pipeline capacity purchased by the City. The 6,100-AF terminal storage reservoir will provide enough storage capacity to meet 2060 peak day demands. As with other supply options, terminal storage siting was not analyzed as part of the SWSP, but conveyance infrastructure costing analyses assumed that it would be located within Norman city limits.

For the 2060 SWSP, it is assumed that the existing Vernon Campbell WTP would be expanded to treat raw water from Southeast Oklahoma under this supply option.

3.3.2.2 Challenges Associated with Co-owner with Oklahoma City for Southeast Oklahoma Raw Water

This water supply option is not without uncertainties, as water rights are currently under dispute between Oklahoma City, the State of Oklahoma, and Native American Tribes. Moreover, permitting for a project of this magnitude (independent of water rights issues) can be difficult and require lengthy analyses.

Since the 2009 study, however, Oklahoma City has continued to pursue planning and preliminary engineering for the Atoka parallel pipeline and Kiamichi basin diversion. The parallel conveyance system is currently in preliminary design. Those efforts, coupled with revisions to participation levels by metro area communities, may result in changes to the pipeline and booster pump station sizing and costing from what was presented in the 2009 study.

3.3.2.3 Opinion of Capital Cost

Capital costs for the project were adjusted from the 2009 study to reflect 2012 dollars and a pro-rata increase in Norman's portion of the project's supply. Other costs were based on unit costs described in Chapter 2.

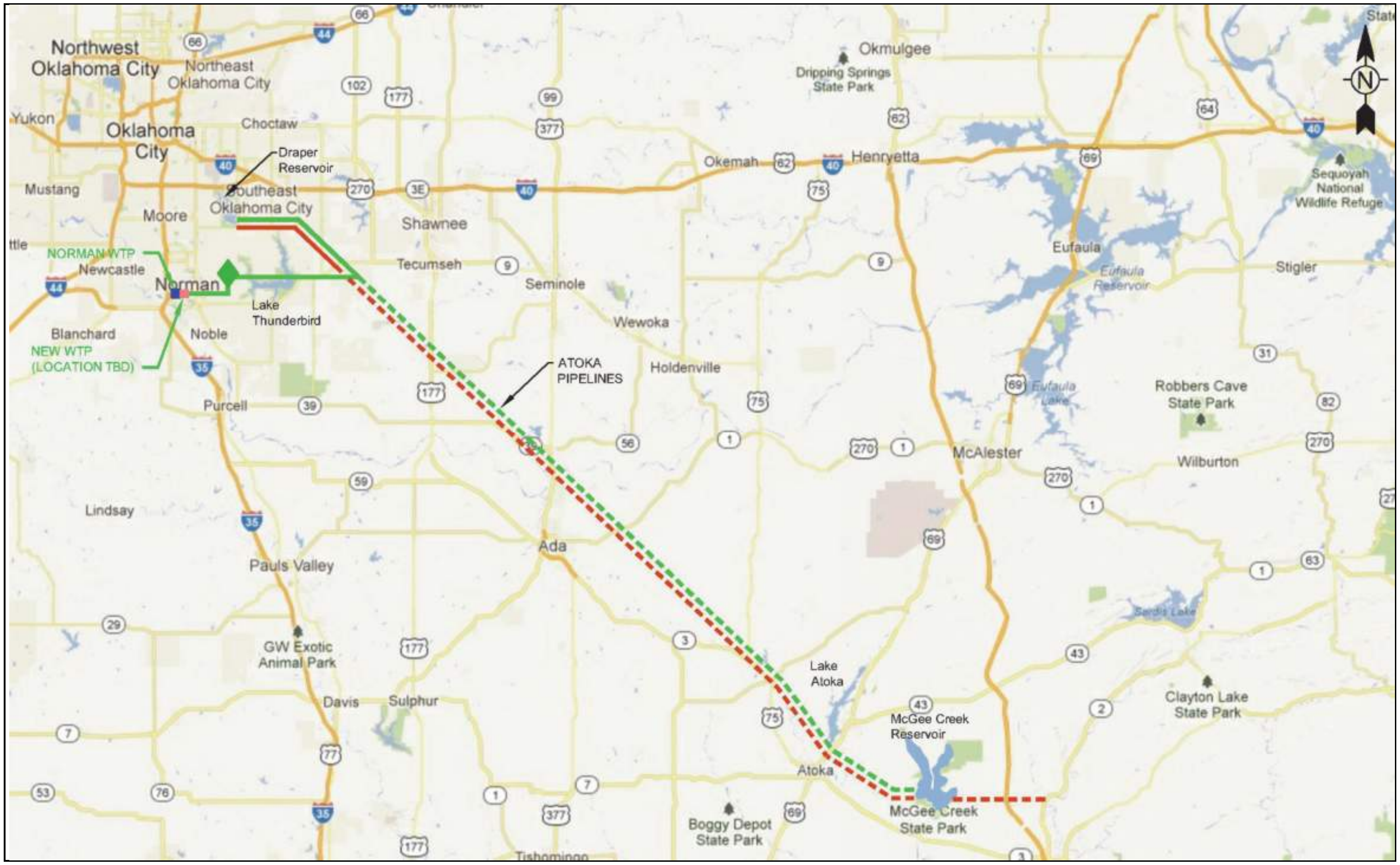
3.3.2.4 Summary of Supply Option

Table 3.14 summarizes information on the Co-owner with Oklahoma City for Raw Water supply source.

Table 3.16 New Regional Water Supply Source – Co-owner with Oklahoma City for Southeast Oklahoma Raw Water

Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	32,600
	mgd	29.1
Percent of proposed firm yield in projected 2060 demands(2)	Percent	100
Raw Water Transmission Distance	Miles	129
Water Treatment Process		Conventional
Known Long-term Reliability Issues		Source reservoirs are constructed. From 2012 Update to OCWP, source basin is not shown to have any shortages through 2060.
Known Implementation Issues		There are known water rights issues that must be resolved. The source project is actively being pursued by Oklahoma City. Land acquisition needed for new terminal storage reservoir
Opinion of Capital Costs	2012 $	$440,000,000
Unit Capital Cost of Source(3)	$/AFY	$14,000

Notes:
(1) Pending negotiations with Oklahoma City, yield could be any amount. For source evaluation, a yield equal to Norman's full projected 2060 demand was used.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.



New Raw Water Line

New Shared Water Line

Existing Raw Water Line

Existing Shared Water Line

Terminal Storage Reservoir 6,100 AF (Location TBD)

Norman Water Treatment Plant

CONCEPTUAL CO-OWNER WITH OKLAHOMA CITY FOR SOUTHEAST OKLAHOMA RAW WATER

FIGURE 3.10

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

3.3.3 Scissortail Reservoir

Scissortail Reservoir is a proposed water supply reservoir on Sandy Creek in Pontotoc County near the City of Ada. A feasibility study for Scissortail Reservoir was initiated in 1984 by the BOR. As part of the 2012 Update of the OCWP, a supplemental report evaluated the viability of major reservoirs. Scissortail Reservoir was included and categorized as a Category 4 reservoir, meaning that it is has the highest potential likelihood of development (OWRB, 2010). The Scissortail Reservoir was most recently evaluated in detail by the City of Ada (Ada, 2009).

3.3.3.1 Description of Supply Source

The proposed Scissortail Reservoir is located approximately three miles west of the City of Ada and approximately 60 miles southeast of Norman. Scissortail Reservoir would have a maximum surface area of 7,027 acres with a storage size of 177,524 acre-feet (Ada, 2009). Scissortail Reservoir has a firm yield of 32,000 AFY (28.55 mgd annual average) (Ada, 2009). This source option is illustrated in Figure 3.11.

The 2060 SWSP assumed that Norman would partner with Ada for development of Scissortail Reservoir, meaning that costs for reservoir development will be shared proportionally between the two cities. Assuming a moderate average demand of 8.7 mgd for the City of Ada (Ada, 2009), the remaining approximately 19.9 mgd annual average yield would available to Norman.

Raw water transmission infrastructure and treatment was assumed to be developed and operated for Norman's benefit only. Raw water pipeline and pump stations are sized to transport supply at the annual average rate. A terminal storage reservoir with approximately 4,200 AF of storage is needed to buffer the constant supply against peak demands. Conventional treatment with softening was assumed based on anticipated water quality.

3.3.3.2 Challenges Associated with Scissortail Reservoir

There are several regulatory hurdles to overcome whenever constructing a new reservoir. Approval may be required from several agencies, such as the OWRB, ODEQ, BOR, and USACE. This is often a lengthy process. Inundation of existing land and/or developments can also be a challenge. These and other challenges associated with development of the proposed reservoir are noted in the 2009 study of the reservoir (Ada, 2009).

3.3.3.3 Opinion of Capital Cost

Capital costs for reservoir development were adjusted from the 2009 study to reflect 2012 dollars, consistent unit pricing, and Norman's pro-rata portion of supply. Other costs were developed as described in Chapter 2.

3.3.3.4 Summary of Supply Option

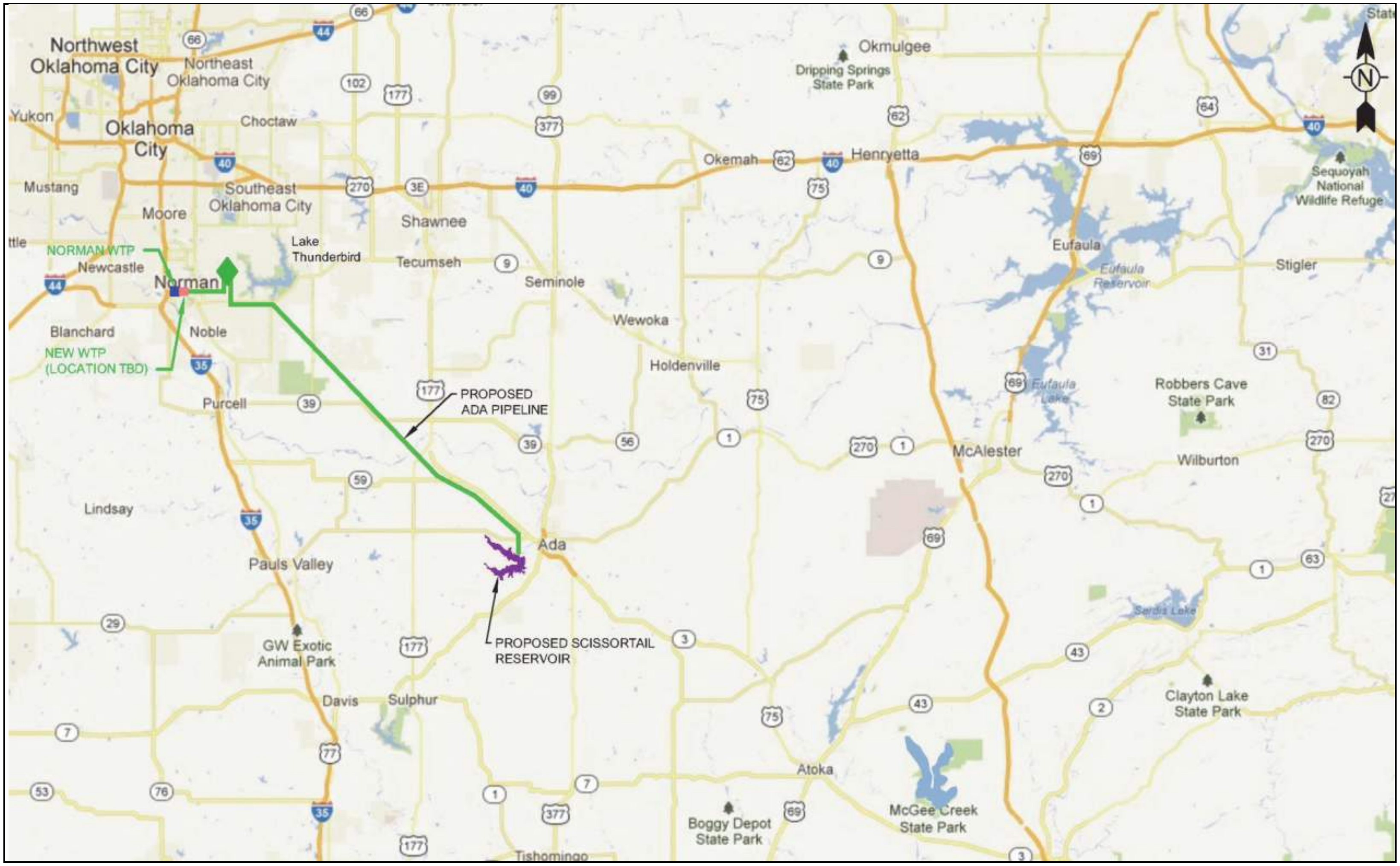
Table 3.17 summarizes information on the Scissortail Reservoir supply option.

Table 3.17 New Regional Water Supply Source – Scissortail Reservoir		
Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman[(1)]	AFY	22,300
	mgd	19.9
Percent of proposed firm yield in projected 2060 demands[(2)]	Percent	68
Raw Water Transmission Distance	Miles	60
Water Treatment Process		Conventional with softening
Known Long-term Reliability Issues		From 2012 Update to OCWP, source basin is shown to have significant shortages by 2060. This reservoir is not built, but previous studies show a reliable yield for its location.
Known Implementation Issues		This was identified as a viable reservoir site, however permitting new reservoir construction will be challenging. Planning studies have been completed and Ada is interested in collaborating.
Opinion of Capital Costs	2012 $	$408,000,000
Unit Capital Cost of Source[(3)]	$/AFY	$18,000

Notes:
(1) Represents firm yield of Scissortail minus a moderate demand estimate for Ada of 8.7 mgd. Demand estimates for Ada vary between 6.7 mgd to 11.9 mgd.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.

3.3.4 Parker Reservoir

Parker Reservoir is a proposed water supply reservoir on Muddy Boggy River in Coal and Hughes Counties. An initial feasibility study for Parker Reservoir was conducted, but further funding for the reservoir was halted in 1985 (NewsOK, 1985). As part of the 2012 Update of the OCWP, a supplemental report evaluated the viability of major reservoirs. Parker Reservoir was included and categorized as a Category 4 reservoir, meaning that it is has the highest potential likelihood of development (OWRB, 2010).



New Raw Water Line

Terminal Storage Reservoir 4,200 AF (Location TBD)

Norman Water Treatment Plant

CONCEPTUAL SCISSORTAIL RESERVOIR

FIGURE 3.11

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

carollo — TETRA TECH

3.3.4.1 Description of Supply Source

The proposed Parker Reservoir is located approximately 15 miles east of the City of Ada and approximately 75 miles southeast of Norman. Parker Reservoir is anticipated to have a maximum surface area of 9,240 acres with a storage of 220,240 acre-feet (OWRB, 2010). Parker Reservoir has a firm yield of 45,900 AFY (OWRB, 2010). This source option is illustrated in Figure 3.12.

For source screening, the 2060 SWSP assumed that Norman would develop Parker Reservoir, meaning that all capital costs for development of the source would be paid for by Norman. Several entities have expressed interest in possible participation in a reservoir at this site, but no entity has expressed definitive participation in the project. Since Parker Reservoir's firm yield exceeds NUA's projected 2060 demands (29.1 mgd annual average), Norman may be able to sell or collaborate with others to reduce source costs. Possible cost benefits of partnering on this project were not included in the 2060 SWSP evaluation.

Raw water transmission infrastructure was sized to meet Norman's projected 2060 annual average demand (29.1 mgd). A terminal storage reservoir with approximately 5,900 AF of storage is needed to buffer the constant supply against peak demands. Conventional treatment with softening was assumed based on anticipated water quality.

3.3.4.2 Challenges Associated with Parker Reservoir

Similar to Scissortail Reservoir, there are several regulatory hurdles to overcome whenever constructing a new reservoir. Approval may be required from several agencies, such as the OWRB, ODEQ, BOR, and USACE. This is often a lengthy process. Inundation of existing land and/or developments can also be a challenge. These and other challenges associated with development of the proposed reservoir are noted in previous studies of the reservoir.

3.3.4.3 Opinion of Capital Cost

Capital costs were developed as described in Chapter 2.

3.3.4.4 Summary of Supply Option

Table 3.18 summarizes information on Parker Reservoir.

Table 3.18 New Regional Water Supply Source – Parker Reservoir		
Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	32,600
	mgd	29.1
Percent of proposed firm yield in projected 2060 demands(2)	Percent	100
Raw Water Transmission Distance	Miles	75
Water Treatment Process		Conventional with softening
Known Long-term Reliability Issues		From 2012 Update to OCWP, source basin is not shown to have any shortages through 2060. This reservoir is not built, but previous studies show a reliable yield for its location.
Known Implementation Issues		This was identified as a viable reservoir site, however permitting new reservoir construction will be challenging. Detailed planning studies have not been completed.
Opinion of Capital Costs(4)	2012 $	$629,000,000
Unit Capital Cost of Source(3)	$/AFY	$19,000

Notes:

(1) Firm yield for Parker Reservoir is estimated at 45,900 AF (or 41 mgd annual average). The yield available to Norman represents the projected 2060 demand for NUA.

(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).

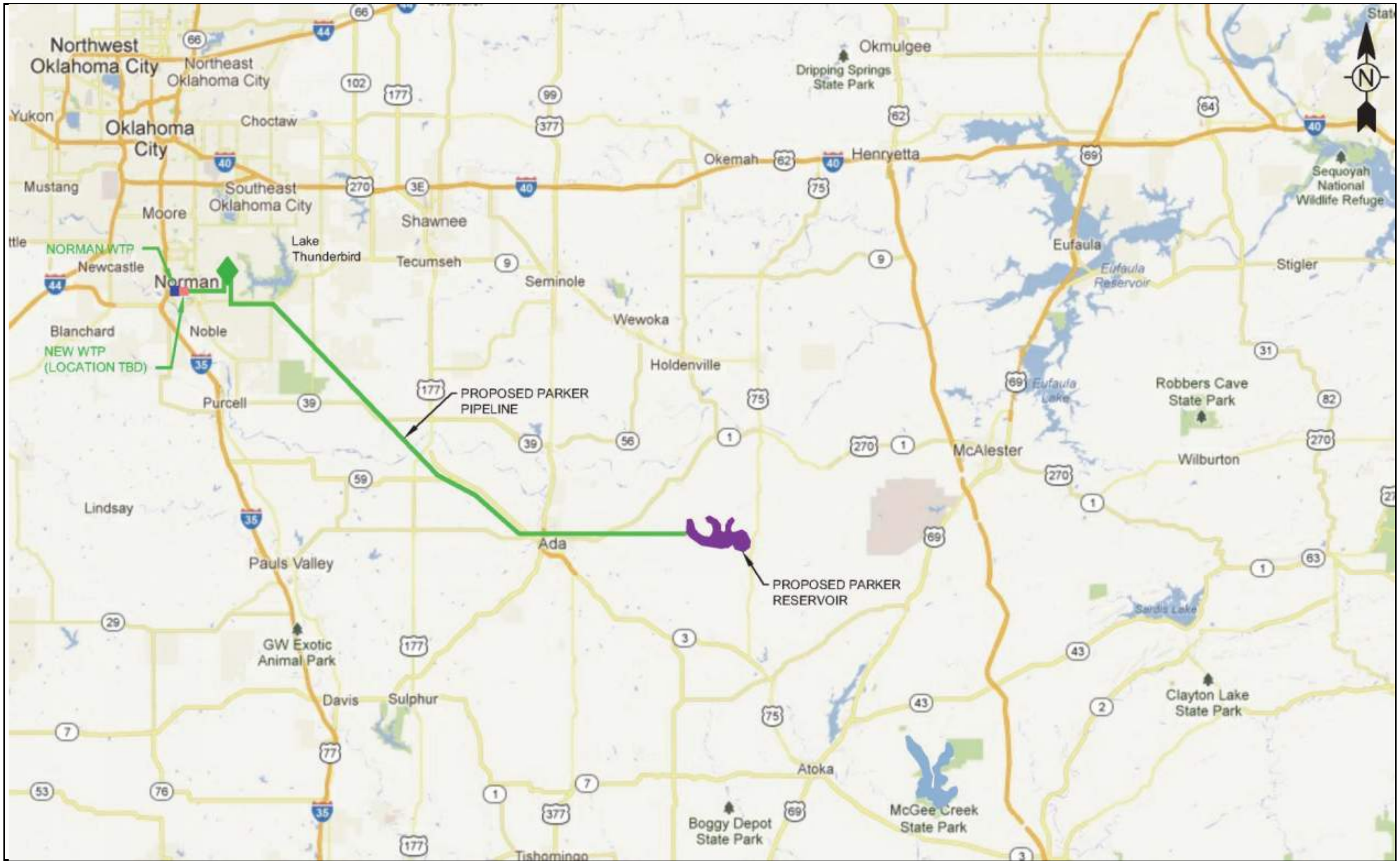
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.

(4) Capital cost represents construction of Parker Reservoir (at its full firm yield) with other infrastructure sized to handle Norman's projected 2060 water demands.

(5) Summed and converted values may vary slightly due to rounding.

3.3.5 Kaw Lake

This section describes the supply option of using raw water from the existing Kaw Lake to meet Norman's long-term water needs. Kaw Lake is located approximately 125 miles north of Norman, 10 miles east of Ponca City, and 50 miles north of Stillwater. Construction was completed in 1976, and Kaw Lake currently serves as Stillwater's primary water source. Kaw Lake is a federally owned reservoir and is operated and maintained by USACE.



New Raw Water Line

Terminal Storage Reservoir 5,900 AF (Location TBD)

Norman Water Treatment Plant

CONCEPTUAL PARKER RESERVOIR

FIGURE 3.12

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

3.3.5.1 Description of Supply Source

Kaw Lake has a total surface area of 17,040 acres and total storage volume of 428,600 AF. The firm yield of the lake is 187,040 AFY (167 mgd annual average). Currently, 141,403 AFY is permitted. There are pending permits for approximately 64,050 AFY; however, discussions with OWRB staff conducted as part of SWSP development indicate that some of these pending permits are no longer relevant. For this study, it was assumed that Kaw Lake could provide 32,551 AFY (29.1 mgd annual average) to Norman.

This water supply option assumes that the pipeline from Kaw Lake to Stillwater would be shared by Stillwater and Norman, as shown in Figure 3.13. From Kaw Lake to Stillwater, the pipeline is estimated to be a 46-mile long, 54-inch diameter line. The costs for this line would be shared between Stillwater and Norman proportionally to their respective anticipated demands. For this study, Stillwater's peak use of the pipeline is assumed to be 27 mgd.

From Stillwater to Norman, an 83-mile long, 36-inch diameter pipeline would have a conveyance capacity of 29.1 mgd. Norman would assume all costs for this portion of pipeline.

The pipeline would end at a new 6,100 AF terminal storage reservoir in Norman, to buffer constant deliveries against variable demands. Again, terminal storage siting was not analyzed as part of the SWSP, but conveyance infrastructure costing analyses assumed that it would be located within Norman city limits. Water would then be piped to a new WTP utilizing conventional treatment with softening, based on available water quality data from Kaw Lake.

3.3.5.2 Challenges Associated with Co-owner with Oklahoma City for Treated Water

Availability of water from Kaw Lake is subject to permit approval by OWRB.

3.3.5.3 Opinion of Capital Cost

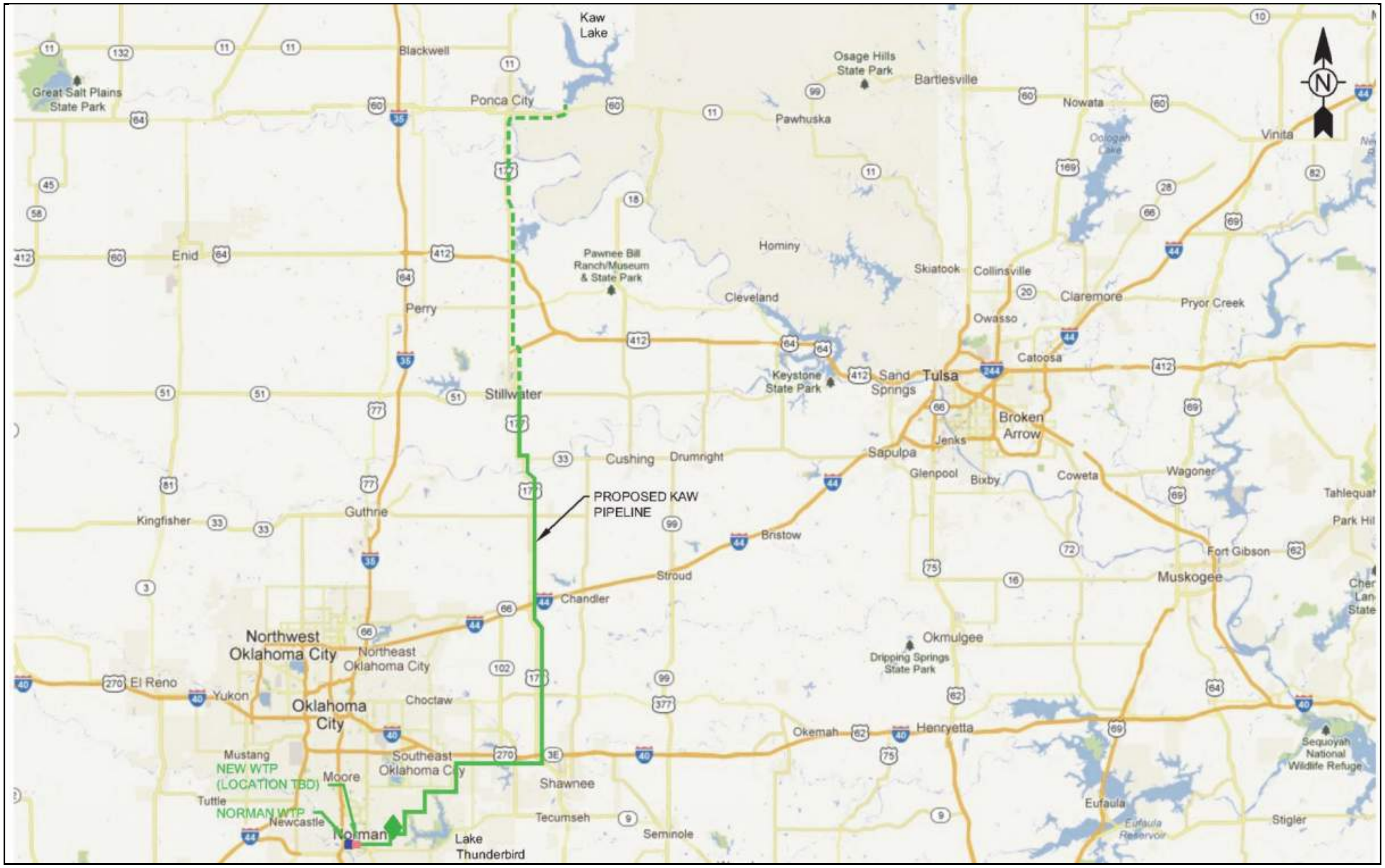
Capital costs were developed as described in Chapter 2. This study assumes that costs for the pipeline from Kaw Lake to Stillwater would be shared based on pro-rata usage by Norman and Stillwater, and that the costs for the pipeline south of Stillwater and other necessary infrastructure would be Norman's sole responsibility.

3.3.5.4 Summary of Supply Option

Table 3.19 summarizes information on Kaw Lake.

Table 3.19 New Regional Water Supply Source – Kaw Lake		
Existing Yield Available to Norman	AFY	N/A
	mgd	N/A
Proposed Firm Yield Available to Norman(1)	AFY	32,600
	mgd	29.1
Percent of proposed firm yield in projected 2060 demands(2)	Percent	100
Raw Water Transmission Distance	Miles	129
Water Treatment Process		Conventional with softening
Known Long-term Reliability Issues		Source reservoir is constructed. From the 2012 Update to the OCWP, the source basin is not shown to have any shortages.
Known Implementation Issues		Resolution of pending water right applications for Kaw Lake supplies is required. Existing reservoir but conveyance will require significant study and institutional cooperation between project participants.
Opinion of Capital Costs	2012 $	$606,000,000
Unit Capital Cost of Source(4)	$/AFY	$19,000

Notes:
(1) The yield available to Norman represents the projected 2060 demand for NUA.
(2) Proposed firm yield divided by Norman's projected 2060 demands (29.1 mgd).
(3) Unit capital cost is capital cost associated with source divided by proposed firm yield. Rehabilitation/replacement costs were not assessed in initial source screening.
(4) Summed and converted values may vary slightly due to rounding.



New Raw Water Line

New Shared Water Line

Terminal Storage Reservoir 6,100 AF (Location TBD)

Norman Water Treatment Plant

CONCEPTUAL KAW LAKE

FIGURE 3.13

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

carollo — TETRA TECH

3.4 INITIAL SOURCE SCREENING

Individual sources were compared and assessed for their viability to meet Norman's long-term needs, in light of four screening criteria selected in consultation with City staff and AHC members. Existing water supply sources and additional conservation were excluded from preliminary screening, as these were automatically considered when developing supply portfolios (Chapter 4). Table 3.20, Table 3.21, Table 3.22, and Table 3.23 provide information for each new local and regional supply source relative to the screening criteria.

The screening criteria were applied to provide a relative comparison of the source options to one another. They include the following:

- Supply Availability (Table 3.20): This criterion considers the question, "Can this source (by itself) meet at least 20 percent of Norman's 2060 demand?" This criterion, while not a strict pass/fail test, is intended to prevent having multiple small water supply sources that would be operationally inefficient and would not reflect the "economy of scale" or the decreased water infrastructure and delivery unit costs associated with a larger project.
- Reliability (Table 3.21): This criterion considers the question, "What is the long-term reliability of the source?" This criterion reflects the need for a secure water supply to meet Norman's long-term water demands, and to consider whether Norman will be able to rely on its firm availability throughout the planning period (year 2060) and beyond.
- Certainty and Timeliness (Table 3.22): This criterion considers the question, "What is the current implementation status of the source? Are there any known implementation issues?" This criterion is used to identify sources that have not been significantly studied or are likely to have permitting or acceptability issues that may delay or prevent implementation. This criterion is used to assess the ability to implement selected long-term source(s) with certainty by the time they are needed.
- Cost-Effectiveness (Table 3.23): This criterion considers the question, "What is the capital cost per acre-foot of firm yield of supply?" This criterion is used to compare the capital cost of each supply source. The unit cost was obtained by dividing conceptual-level project capital costs ($) by the firm yield (AFY). Normalizing costs to a unit basis ($/AFY) provides an objective comparison between the sources with different supply yields. While source screening was conducted using capital costs, portfolio evaluations also considered annual operation and maintenance costs.

Table 3.24 summarizes preliminary screening and identifies the supply sources that were recommended as being most viable for Norman, and thus suitable for portfolio development.

Table 3.20 Preliminary Screening Criteria – Supply Availability		
Source Name	**Firm Yield as Percent of 2060 Demand**	**Notes**
Lake Thunderbird Spillage	20%	Constrained to 6 mgd firm yield based on size and cost of infrastructure required; additional yield possible with upsized infrastructure.
Lake Thunderbird Augmentation (IPR)	52%	Assumes 15 mgd of water reclaimed from the Norman WRF is available for recovery at lake by 2060.
Groundwater Recharge (IPR)	35%	Assumes 17 mgd WRF effluent and 60 percent recapture rate (10.2 mgd) by 2060.
Canadian River Diversion Option 1(1)	21%	Constrained to 6 mgd firm yield based on size and cost of infrastructure required; additional yield possible with upsized infrastructure.
Non-potable Reuse	5%	Sized based on list of potential customers for first phase of reuse project plus excess pipeline capacity for future customers.
Stormwater Capture and Reuse	20%	Constrained to 6 mgd firm yield based on size and cost of infrastructure required; additional yield possible with upsized infrastructure.
Co-Owner with Oklahoma City for Southeast Oklahoma Treated Water	100%	29.1 mgd available to Norman from regional project.
Co-Owner with Oklahoma City for Southeast Oklahoma Raw Water	100%	29.1 mgd available to Norman from regional project.
Scissortail Reservoir	68%	Assumes full amount of Scissortail firm yield available (28.6 mgd) minus 8.7 mgd allocated to Ada.
Parker Reservoir	100%	Firm yield of Parker Reservoir exceeds Norman's 2060 demand; partnership opportunities may exist.
Kaw Lake	100%(2)	Resolution of several pending permit applications could affect availability to Norman. Existing permits are for about 140,000 AFY out of the total yield of 187,040 AFY.

Notes:
(1) Three options were evaluated for diversion of the Canadian River. Option 1 represents the best of the three options reviewed from both a cost perspective and water transmission/distribution perspective. It contains a new terminal reservoir and WTP on the west side of Norman. Diversions downstream of Norman could increase yield slightly, but would require an Eastside terminal storage reservoir and distribution system improvements, or significant transmission piping to the Westside terminal storage reservoir.
(2) Assumes that none of the pending permit applications will be granted. Should all pending permit applications be approved, there would be no available supply for Norman.

Table 3.21 Preliminary Screening Criteria – Reliability		
Source Name	**Reliability Score(1)**	**Notes**
Lake Thunderbird Spillage	2	Reliability is a function of terminal storage and infrequency of spills.
Lake Thunderbird Augmentation (IPR)	4	WRF effluent is highly reliable.
Groundwater Recharge (IPR)	4	WRF effluent is highly reliable.
Canadian River Diversion Option 1	1	From the 2012 Update to OCWP, this source basin is shown to have some shortages by 2060. Reliability is a function of terminal storage. Minor increases in yield could be achieved if diversion point was moved to be downstream of Norman.
Non-potable Reuse	4	WRF effluent is highly reliable.
Stormwater Capture and Reuse	2	Reliability is a function of terminal storage and variability in local precipitation.
Co-Owner with Oklahoma City for Southeast Oklahoma Treated Water	5	Source reservoirs are constructed. From the 2012 Update to OCWP, this source basin is not shown to have any shortages through 2060.
Co-Owner with Oklahoma City for Southeast Oklahoma Raw Water	5	Source reservoirs are constructed. From the 2012 Update to OCWP, this source basin is not shown to have any shortages through 2060.
Scissortail Reservoir	3	From the 2012 Update to OCWP, this source basin is shown to have significant shortages by 2060. No historical operation data available (this reservoir is not built yet) for this reservoir, but previous studies show a reliable yield for this location.
Parker Reservoir	4	From the 2012 Update to OCWP, this source basin is not shown to have any shortages through 2060. No historical operation data available (this reservoir is not built yet).
Kaw Lake	5	Source reservoir is constructed. From the 2012 Update to OCWP, this source basin is not shown to have any shortages through 2060.

Notes:
(1) Relative ranking where 1 represents the least reliable source and 5 represents the most reliable source.

Table 3.22 Preliminary Screening Criteria – Certainty and Timeliness

Source Name	Certainty and Timeliness Score(1)	Notes
Lake Thunderbird Spillage	1	Source has not been studied or permitted. OWRB will have to confirm than no downstream water rights holders will be impacted. Concurrence and approval from COMCD, OWRB, BOR, and USACE would be needed. Significant land acquisition required for terminal storage.
Lake Thunderbird Augmentation (IPR)	2	Lack of IPR rules in Oklahoma, and designation of Lake Thunderbird as a SWS brings uncertainty in discharge water quality requirements. An agreement with COMCD and other member cities for discharges and additional storage and diversions may be necessary. Costs for increased use of the lake's capacity have not been established. Public outreach will be necessary to secure public acceptance.
Groundwater Recharge (IPR)	1	Lack of permitting precedent or regulations for water quality and quantity. Subsequent study is needed to confirm recharge rates. Significant number of new well sites are required, with associated land acquisition needs.
Canadian River Diversion Option 1	2	Requires significant study of feasibility. Significant land acquisition needed for terminal storage.
Non-potable Reuse	5	ODEQ rules are in place for non-potable reuse. Significant ability to control implementation locally. Potential requirements for continued discharges from WRF to Canadian River.
Stormwater Capture and Reuse	2	Requires significant study of feasibility. Significant land acquisition needed in developed areas for transmission and terminal storage.
Co-Owner with Oklahoma City for Southeast Oklahoma Treated Water	4	There are known water rights issues that must be resolved. The source project is actively being pursued by Oklahoma City.
Co-Owner with Oklahoma City for Southeast Oklahoma Raw Water	4	There are known water rights issues that must be resolved. The source project is actively being pursued by Oklahoma City.

Table 3.22 Preliminary Screening Criteria – Certainty and Timeliness		
Source Name	**Certainty and Timeliness Score(1)**	**Notes**
Scissortail Reservoir	3	This was identified as a viable reservoir site, however permitting new reservoir construction will be challenging. Planning studies have been completed and Ada is interested in collaborating.
Parker Reservoir	3	This was identified as a viable reservoir site, however permitting new reservoir construction will be challenging. Detailed planning studies have not been completed.
Kaw Lake	4	Resolution of pending water right applications for Kaw Lake supplies is required. Existing reservoir but conveyance will require significant study and institutional cooperation between project participants.

Notes:

(1) Relative ranking where 1 represents the most significant implementation issues and 5 represents the least significant implementation issues.

Table 3.23 Preliminary Screening Criteria – Cost-Effectiveness

Source Name	Capital Unit Cost ($1000/AFY)	Notes on Criteria Rating
Lake Thunderbird Spillage	$79	Costs impacted by large size of terminal storage reservoir necessary to get firm yield and the necessity to capture after it spills.
Lake Thunderbird Augmentation (IPR)	$8.2	
Groundwater Recharge (IPR)	$32	Cost impacted by level of treatment anticipated.
Canadian River Diversion Option 1	$39	Costs impacted by large size of terminal storage reservoir necessary to get firm yield.
Non-potable Reuse	$22	Costs impacted by transmission infrastructure necessary to get supply to customers when and where needed.
Stormwater Capture and Reuse	$190	Costs impacted by large size of terminal storage reservoir necessary to get firm yield.
Co-Owner with Oklahoma City for Southeast Oklahoma Treated Water	$12	
Co-Owner with Oklahoma City for Southeast Oklahoma Raw Water	$14	Includes costs for terminal storage reservoir.
Scissortail Reservoir	$18	Assumes participation with Ada.
Parker Reservoir	$19	
Kaw Lake(1)	$19	Assumes participation with Stillwater.

Notes:

(1) Kaw Lake capital unit cost does not include any debt service or other costs that may be incurred, but may be updated as information becomes available.

Table 3.24 Preliminary Screening Criteria – Summary		
Source Name	**Retained for Use in Portfolio Analyses?**	**Explanatory Notes**
Lake Thunderbird	Yes	Existing local source
Garber-Wellington Aquifer Wells	Yes	Existing local source
Conservation	Yes	Existing local source
Lake Thunderbird Spillage	No	Very high unit cost, large uncertainty related to implementation, and uncertainty of long-term reliability remove this source from further evaluation.
Lake Thunderbird Augmentation (IPR)	Yes	Low unit cost, uncertainty for implementation, however community benefits and efficiency justify further evaluation.
Groundwater Recharge (IPR)	No	High unit cost and significant uncertainty for implementation remove this source from further evaluation; Lake Thunderbird Augmentation option for IPR is more implementable and significantly more cost-effective.
Canadian River Diversion Option 1	No	High unit cost and significant uncertainty for implementation remove this source from further evaluation.
Non-potable Reuse	Yes	Even with high unit cost, this source has community benefits and efficiency that justify further evaluation.
Stormwater Capture and Reuse	No	Very high unit cost, uncertainty related to implementation, and uncertainty of long-term reliability remove this source from further evaluation.
Co-Owner with Oklahoma City for Southeast Oklahoma Treated Water	Yes	Low unit cost, detailed studies completed, and project proponents moving forward toward implementation.
Co-Owner with Oklahoma City for Southeast Oklahoma Raw Water	Yes	Low unit cost, detailed studies completed, and project proponents moving forward toward implementation.
New Out of Basin Reservoir	Yes	Scissortail and Parker scored similarly against screening criteria, and were thus combined into “New Out of Basin Reservoir” source for purposes of portfolio evaluations
Kaw Lake	Yes	Existing reservoir, low unit costs, and opportunities for regional partnerships for implementation

WATER SUPPLY PORTFOLIOS

Using the results of the individual supply source screening, several water supply portfolios were developed. Each portfolio uses one or more of the viable supply sources identified via the source screening to meet the entire 2060 projected demand for the NUA service area reliably. These portfolios were analyzed, compared, and refined using detailed evaluation criteria. This chapter describes the portfolio evaluation criteria, development and evaluation of portfolios, and the results of portfolio analysis.

4.1 OBJECTIVES DEVELOPMENT AND WEIGHTING

Evaluation criteria, sometimes referred to as “objectives” for water supply, were used as the basis for evaluating and comparing a range of water supply portfolios. The evaluation process is described briefly below.

- Objectives, sub-objectives, and performance measures were defined to provide a common basis for detailed evaluation and comparison of supply portfolios.
- The primary objectives were comparatively weighted using a ”paired comparison” methodology.
- Portfolios were first scored separately for each objective, independent of the objectives’ relative weight, then ranked using the individual objectives’ weights developed in the preceding step.

The objectives, sub-objectives, and performance measures shown in Table 4.1 represent the factors that were used to evaluate and compare supply portfolios.

In nearly all decision-making processes, the objectives are not all equally important. Some objectives may be more relevant for a given stakeholder than others. As an example, for a given individual, environmental stewardship may be more important than timely implementation. Moreover, these relative weightings vary from person to person, reflecting each individual’s values. Thus, weighting objectives is necessary to reflect better the range of values and preferences present in the decision-making process.

For the SWSP, the relative weights of the primary objectives were determined through a process known as “paired comparison.” This method is based on the fact that when presented with a series of objectives, a decision as to the relative importance of those objectives against each other is made more simply when the objectives are compared separately in pairs. The results of the comparison of each pair of objectives are later aggregated to determine the overall importance of every objective. Results from the paired comparison exercise are available in Appendix R.

Table 4.1 Portfolio Evaluation Criteria		
Objective	**Sub-objective**	**Performance Measure**
Affordability *"What will it cost to reliably provide treated water?"*	✓ Minimize capital cost	✓ Unit capital cost including diversion, transmission, and treatment ($/AFY of firm yield using 2012 non-escalated dollars)
	✓ Minimize life-cycle cost	✓ 2060 O&M ($M/Yr)
Long-Term Supply Reliability *"Will we be able to reliably meet our demand?"*	✓ Minimize supply shortages	✓ Weighted average of 2060 shortages (frequency) in basins of origin (per 2012 OCWP Watershed Planning Regional Reports)
		✓ Supply diversity in terms of number of sources and types of sources (qualitative score)
		✓ Percent of supply portfolio coming from Garber-Wellington Aquifer
	✓ Infrastructure reliability	✓ Raw water transmission distance (mi)
		✓ Transmission complexity, considering length of pipeline and number/complexity of pumping operations (qualitative score)
		✓ Treatment complexity (qualitative score)
		✓ Degree of redundancy, e.g., parallel pipelines (qualitative score)
Phasing Potential *"Can we defer capital and increase the supply over time?"*	✓ Defer capital costs	✓ Ability to phase implementation and construction (qualitative score)
	✓ Provide for future needs	✓ Ability to access additional supplies beyond projected 2060 demands (qualitative score)
Timely Implementation and Certainty *"Are we certain we can bring the supply online by the time it is needed?"*	✓ Reduce institutional complexity and increase local control	✓ Number of agency/utility partners (facility owners and/or project co-participants) (qualitative score)
		✓ Percent of supply sourced in Norman
		✓ Public/political acceptability (qualitative score)
		✓ Vulnerability to potential future changes in water rights allocations and water quality standards (qualitative score)
	✓ Timely implementation	✓ Project development status in 2012 for new supplies in portfolio (qualitative score)
		✓ Amount and ease of environmental permitting, water rights acquisition, and land acquisition (qualitative score)

Table 4.1 Portfolio Evaluation Criteria		
Objective	**Sub-objective**	**Performance Measure**
Efficient Use of Water Resources *"Are we making the best use of the available resources?"*	✓ Maximize water use efficiency	✓ Percent of total demand met by non-potable reuse in 2060
		✓ Percent of total demand met by indirect reuse (supply augmentation) in 2060
	✓ Increase conservation	✓ Percent reduction from baseline demand due to additional conservation measures and programs
Environmental Stewardship *"Are we preserving our environmental resources?"*	✓ Minimize energy consumption	✓ Pumping head per unit supply (ft/1000 AFY)
	✓ Minimize temporary construction impacts and environmental mitigation needs	✓ Amount of land disturbed during construction (ac)
	✓ Minimize permanent ecosystem impacts	✓ Environmental impacts (qualitative score)
	✓ Increase use of renewable resources	✓ Renewable supply score for portfolio (qualitative score)
Treated Water Quality Aesthetics *"Will our customers be satisfied with the quality of the water we deliver?"*	✓ Achieve secondary MCLs	✓ Blended average conductivity (µg/L)
	✓ Minimize taste and odor potential	✓ Percent of supply originating from surface water sources
Community Values (Recreation, Aesthetics, and Property Rights) *"Will our community gain value from this alternative, while protecting property rights?"*	✓ Impact on non-water supply benefits	✓ Perceived impacts to recreation and aesthetics (qualitative score)
	✓ Protection of property rights	✓ Potential impact to property rights (qualitative score)

Members of NUA staff, trustees and chairman, and members of the SWSP Ad Hoc Committee were invited to complete the paired comparison exercise. This exercise and the portfolio evaluation process is intended to show the range of values present in the community and to seek out two or more portfolios that robustly meet the range of values expressed by community members.

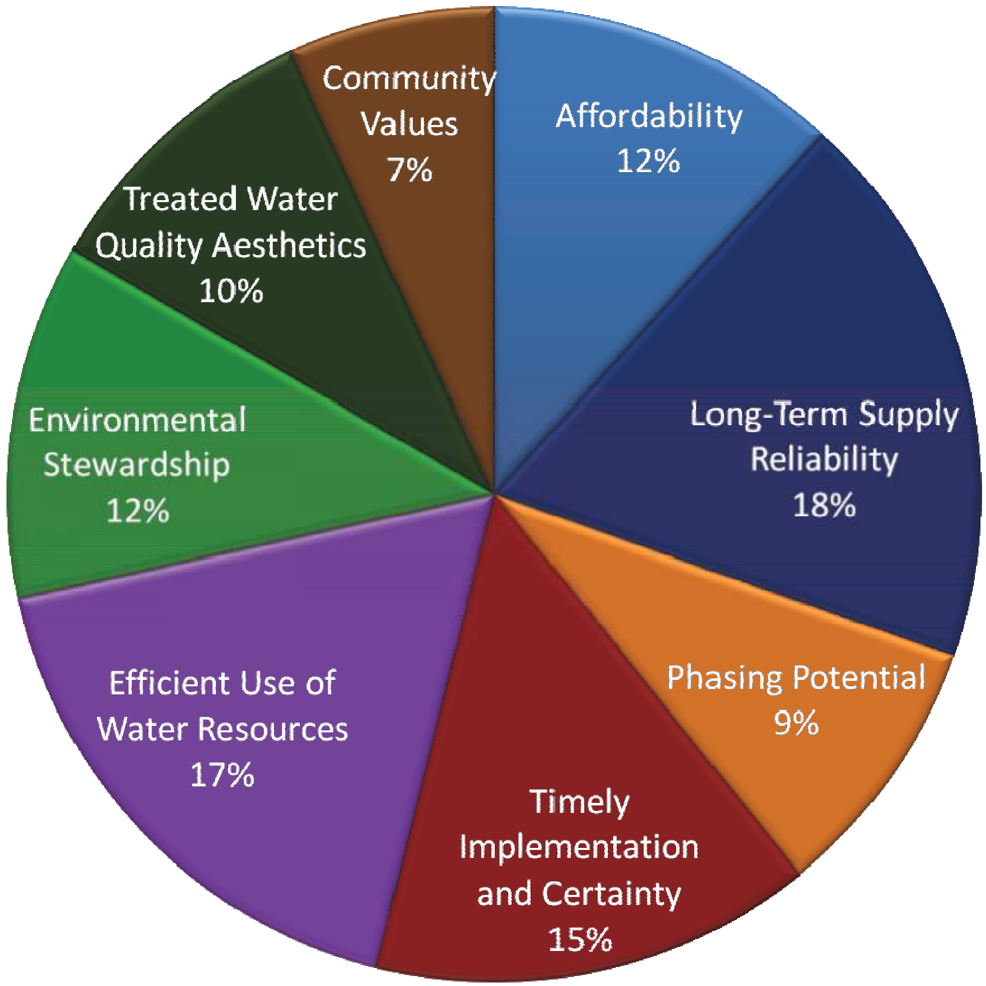
In the paired comparison exercise, all possible pairs of primary objectives are identified. Each participant chooses which objective from each pair is more important to him or her. The results are summed to get a relative percentage weight of importance for each objective. Higher percent weightings indicate a higher importance. Figure 4.1 summarizes the major objectives and their relative importance, or weight, averaged for those who participated in the weighting exercise. This weighting profile was used as the primary basis for comparing and ranking portfolios. However, discussions at AHC meetings and in interim analyses assessed the sensitivity to changes in the objective weightings, to understand the impact – if any – on the relative ranking in response to changes in objective weighting profiles. The final recommended portfolios were found to be generally insensitive to minor modifications in weighting profiles. This suggests that the recommended portfolios are diverse and offer multiple benefits, balancing the tradeoffs between economic costs and non-monetary benefits.

4.2 WATER SUPPLY PORTFOLIOS

Initially, six portfolios were developed that looked at extremes in long-range water supply for Norman. For example, Portfolio 5 looked at meeting all of Norman's 2060 water demand using a new out-of-basin reservoir. An additional eight portfolios, referred to as "hybrid portfolios" because they took elements of the initial six portfolios and recombined them into new portfolios, were developed over the course of SWSP analyses.

The hybrid portfolios were assembled with the intent of combining the strongest regional and local sources in order to determine the most robust long-range water supply options to meet NUA's long-term water needs. Assumptions regarding individual supply sources detailed in Chapters 2 and 3 of this report were carried forth for the portfolio analyses. Individual supplies were combined into the portfolios, adjusting the individual sources' sizing (annual average or peak day yields) so that each portfolio would meet the projected 2060 demands. Capital and operational costs were adjusted to reflect the source supply amounts utilized in the portfolio. Table 4.2 summarizes the amount of water provided by each source, on an average annual amount, in each of the 14 portfolios. All portfolios provide an annual average total supply of 29.1 mgd and a peak day supply of 55.3 mgd, matching the 2060 higher-end demand projections. To the degree that lower demands are observed (e.g., less conversion of domestic wells to NUA water service), implementation of new supply projects or expansions can be delayed or deferred.

Detailed portfolio evaluation workbooks are provided in Appendix B.



WEIGHTING FOR PORTFOLIO EVALUATION CRITERIA

FIGURE 4.1

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

carollo

Table 4.2 Portfolio Summary

Portfolio ID	2060 Supply by Source (mgd)												
		Lake Thunderbird	Active Garber-Wellington Wells (with treatment)	Inactive Garber-Wellington Wells (with treatment)	New Garber-Wellington Wells (with treatment)	Additional Conservation	Non-potable Reuse	Lake Thunderbird Augmentation (IPR)	Treated Water from Oklahoma City (wholesale)	Treated Water from Oklahoma City (co-owner)	Raw Water from Oklahoma City (co-owner)	New Out of Basin Reservoir (Parker or Scissortail)	Kaw Lake
P1	Annual Average	6.1	6.0	2.1		1.0	0.8	12.4					
	Peak	17	9.0	2.7		1.5	4.6	20.5					
P2	Annual Average	6.1	6.0	2.1		1.0	0.8		13.1				
	Peak	17	9.0	2..7		1.5	4.6		20.5				
P3	Annual Average									29.1			
	Peak									55.3			
P4	Annual Average										29.1		
	Peak										55.3		

Table 4.2 Portfolio Summary

Portfolio ID	2060 Supply by Source (mgd)												
		Lake Thunderbird	Active Garber-Wellington Wells (with treatment)	Inactive Garber-Wellington Wells (with treatment)	New Garber-Wellington Wells (with treatment)	Additional Conservation	Non-potable Reuse	Lake Thunderbird Augmentation (IPR)	Treated Water from Oklahoma City (wholesale)	Treated Water from Oklahoma City (co-owner)	Raw Water from Oklahoma City (co-owner)	New Out of Basin Reservoir (Parker or Scissortail)	Kaw Lake
P5	Annual Average											29.1	
	Peak											55.3	
P6	Annual Average												29.1
	Peak												55.3
P7	Annual Average	6.1				1.0	0.8			21.2			
	Peak	17				1.5	4.6			32.2			
P8	Annual Average	6.1				1.0		17.0	5.0				
	Peak	17				1.5		29.3	7.5				

Table 4.2 Portfolio Summary

Portfolio ID		2060 Supply by Source (mgd)											
		Lake Thunderbird	Active Garber-Wellington Wells (with treatment)	Inactive Garber-Wellington Wells (with treatment)	New Garber-Wellington Wells (with treatment)	Additional Conservation	Non-potable Reuse	Lake Thunderbird Augmentation (IPR)	Treated Water from Oklahoma City (wholesale)	Treated Water from Oklahoma City (co-owner)	Raw Water from Oklahoma City (co-owner)	New Out of Basin Reservoir (Parker or Scissortail)	Kaw Lake
P9	Annual Average	6.1	6.0	2.1	13.1	1.0	0.8						
	Peak	17	9.0	2.7	20.5	1.5	4.6						
P10	Annual Average	6.1	6.0	2.1		1.0	0.8					13.1	
	Peak	17	9.0	2.7		1.5	4.6					20.5	
P11	Annual Average	6.1	6.0	2.1		1.0	0.8			13.1			
	Peak	17	9.0	2.7		1.5	4.6			20.5			
P12	Annual Average	6.1				1.0						22.0	
	Peak	17				1.5						36.8	

Table 4.2 Portfolio Summary

Portfolio ID		2060 Supply by Source (mgd)											
		Lake Thunderbird	Active Garber-Wellington Wells (with treatment)	Inactive Garber-Wellington Wells (with treatment)	New Garber-Wellington Wells (with treatment)	Additional Conservation	Non-potable Reuse	Lake Thunderbird Augmentation (IPR)	Treated Water from Oklahoma City (wholesale)	Treated Water from Oklahoma City (co-owner)	Raw Water from Oklahoma City (co-owner)	New Out of Basin Reservoir (Parker or Scissortail)	Kaw Lake
P13	Annual Average	6.1	6.0	2.1		1.0	0.8				13.1		
	Peak	17	9.0	2.7		1.5	4.6				20.5		
P14	Annual Average	6.1	6.0	2.1	2.0	1.0	0.8	11.1					
	Peak	17	9.0	2.7	3.0	1.5	4.6	17.5					

4.2.1 Portfolio 1

Portfolio 1 is a diverse portfolio that maximizes use of local sources like Lake Thunderbird, groundwater wells, and use of reclaimed water. The available supply from Lake Thunderbird is based on Norman's allocation of the firm yield of the reservoir. It is assumed that all of the groundwater wells (active and inactive) will be piped together and receive centralized treatment for chromium-6 and arsenic. Reclaimed water will be used for augmenting Lake Thunderbird (with treatment to address anticipated regulations for IPR plus non-regulated contaminants like EDCs and pharmaceutically-active compounds) and for non-potable purposes like irrigation (with treatment needed to comply with ODEQ NPR regulations). Conservation programs will be expanded to provide additional water savings beyond Norman's existing programs.

Table 4.3 summarizes key attributes and a comparison of Portfolio 1 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio offers a locally diverse supply portfolio combining surface, groundwater, and reclaimed water supplies within or close to the city. Because supplies are local, there is less energy required for bringing raw water to treatment/distribution facilities. However, this portfolio requires three unique treatment processes: continued potable water treatment for Lake Thunderbird, new potable treatment for groundwater supplies, and new treatment for reclaimed water tailored to requirements for Lake Thunderbird augmentation and for NPR. While NPR is allowed and regulated by ODEQ, there are no current regulations allowing for IPR or precedent for discharging to a SWS (Lake Thunderbird augmentation). In the 2060 SWSP, IPR treatment was assumed to not only meet anticipated regulations but also address non-regulated contaminants like EDCs. However, even with this conservative planning approach, the lack of current regulations leaves this portfolio with uncertainties regarding timely implementation and costs.

Table 4.3 Portfolio 1 – Maximize Local Sources[(1)]

Affordability[(2)]	Unit Capital Cost ($M/AFY)	$7,672
	2060 O&M Cost ($/yr)	$21.3
	Capital Cost ($M)	$250
Long-Term Supply Reliability	Diversity of Supply Sources	Most Diverse
	Complexity of Transmission System	Least Complex
	Complexity of Treatment	More Complex
	Percent of Supply from Garber-Wellington Aquifer	29%
Phasing Potential	Ability to Phase Projects	Best Opportunity
	Ability to Meet Demands Beyond 2060	Good Opportunity

Table 4.3 Portfolio 1 – Maximize Local Sources[1]		
Timely Implementation and Certainty	Percent of Local Supply	100%
	Vulnerability to potential future changes in water rights allocations and water quality standards	More Vulnerable
	Project development status in 2012	Lack of existing regulations and/or no detailed studies[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	49%
Environmental Stewardship	Energy required for operation	Lower energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of Lake Thunderbird Augmentation and chromium-6 MCL.

4.2.2 Portfolio 2

Portfolio 2 is a diverse portfolio that minimizes capital investment through purchasing treated water from Oklahoma City on a wholesale basis. Similar to Portfolio 1, the available supply from Lake Thunderbird is based on Norman's allocation of the firm yield of the reservoir, it is assumed that all of the groundwater wells will be piped together and receive centralized treatment, and reclaimed water will be used for non-potable purposes like irrigation. Conservation programs will expand to offer some additional water savings. The remainder of 2060 demand will be met by purchasing treated water from Oklahoma City utilizing the terms of Oklahoma City's Take or Pay wholesale rate structure. This has a lower rate than the City's current Demand Service contract with Oklahoma City but requires a more consistent usage of water. Norman will likely need to use water from Oklahoma City to meet base demands and meet peak demands using other supply sources, which is the opposite of current practice of using water from Oklahoma City to meet seasonal peak demands only.

Table 4.4 summarizes key attributes and a comparison of Portfolio 2 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio offers a diverse supply portfolio combining surface, groundwater, and small amounts of reclaimed water supplies. All but purchasing water from Oklahoma City are considered local sources. This portfolio has less complicated treatment than Portfolio 1 in that it requires continued water treatment for Lake Thunderbird, new treatment for groundwater supplies, and new treatment for reclaimed water (though this treatment will be less complex and smaller quantities than that proposed for Lake Thunderbird augmentation). Portfolio 2 requires purchasing a significant amount of water from Oklahoma City to meet Norman's 2060 demands. While this source has minimal capital costs for Norman directly, the seller, Oklahoma City, is able to charge a water rate that allows them to cover their costs of supply, meaning that the rate includes their capital and operational costs for acquiring, transporting, treating, and distributing water to their customers. Over time, the cumulative annual costs become significant and would eventually exceed the cumulative capital and annual costs of other higher-capital portfolios.

Table 4.4 Portfolio 2 – Minimize Capital Cost[(1)]

Affordability[(2)]	Unit Capital Cost ($M/AFY)	$4,367
	2060 O&M Cost ($/yr)	$53.0
	Capital Cost ($M)	$140
Long-Term Supply Reliability	Diversity of Supply Sources	Good Diversity
	Complexity of Transmission System	Average Complexity
	Complexity of Treatment	Average Complexity
	Percent of Supply from Garber-Wellington Aquifer	29%
Phasing Potential	Ability to Phase Projects	Best Opportunity
	Ability to Meet Demands Beyond 2060	Average Opportunity
Timely Implementation and Certainty	Percent of Local Supply	53%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average Vulnerability
	Project development status in 2012	Detailed study completed and implementation initiated by project sponsor[(3)]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	3%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	Fewer impacts
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Reflects understanding of purchasing water from Oklahoma City as wholesale customer.

4.2.3 Portfolios 3, 4, 5, and 6

Portfolios 3, 4, 5, and 6 are single source portfolios, meaning that Norman would meet its entire 2060 demand using a single supply source. These portfolios were evaluated primarily to determine which regional source best meets Norman's detailed supply objectives, described in Table 4.1. Portfolios 3 and 4 evaluate being a co-owner with Oklahoma City for water supply infrastructure as part of Oklahoma City's plans to expand its southeast

Oklahoma supplies. Portfolio 3 includes treatment of those supplies at Oklahoma City's Draper WTP, while Portfolio 4 would deliver raw water to Norman for treatment at a NUA facility. Portfolio 5 assesses obtaining water from a new out-of-basin reservoir (either Scissortail or Parker). Portfolio 6 evaluates conveying raw water from Kaw Lake to Norman for treatment and distribution, in partnership with Stillwater.

While these portfolios have a variety of supply sources, there are some similarities between them. None of these four portfolios has diverse supplies. All supplies are located a considerable distance from Norman, and thus have higher transmission costs (both in capital and operational costs).

There also are some significant differences between these portfolios. Treatment complexity varies based on water quality of supply, with anticipated raw water quality being better in Portfolios 3 and 4 and poorer in Portfolios 5 and 6. Portfolio 5 requires constructing a new source reservoir, which is a timely, complicated, and expensive process. However, it would likely offer the ability to meet Norman's demands beyond 2060. Alternatively, extra water could be sold (either wholesale or as co-owner) to other entities. Portfolios 3 and 4 rely on collaborating with Oklahoma City in a regional supply project. Oklahoma City is pursuing bringing water from Southeast Oklahoma to Central Oklahoma for treatment and distribution. There are known permitting and water rights issues that must be resolved in order to develop this water supply. Portfolio 6 utilizes an existing reservoir, but the conveyance distance is considerable and will require significant study before implementation. The unknowns for each of Portfolios 3, 4, 5, and 6 factor into the key attributes listed in Table 4.5, Table 4.6, Table 4.7, and Table 4.8. The complete set of scores for each of these portfolios relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B.

Table 4.5 Portfolio 3 – Regional Option with Oklahoma City Treated Water(1)

Affordability(2)	Unit Capital Cost ($M/AFY)	$12,494
	2060 O&M Cost ($/yr)	$23.6
	Capital Cost ($M)	$410
Long-Term Supply Reliability	Diversity of Supply Sources	Poor diversity
	Complexity of Transmission System	More Complex
	Complexity of Treatment	Least Complex
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Average Opportunity
	Ability to Meet Demands Beyond 2060	Average Opportunity

Table 4.5 Portfolio 3 – Regional Option with Oklahoma City Treated Water[1]		
Timely Implementation and Certainty	Percent of Local Supply	0%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Least Vulnerable
	Project development status in 2012	Some studies conducted and permitting process established[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	0%
Environmental Stewardship	Energy required for operation	Average energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	High likelihood
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	Fewer impacts

Notes:

(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).

(2) All costs are in 2012 dollars (ENR 5416).

(3) Reflects status of bringing water from Southeast Oklahoma. There are uncertainties associated with water rights, however the process and treatment required is well understood.

Table 4.6 Portfolio 4 – Regional Option with Oklahoma City Raw Water[1]		
Affordability[2]	Unit Capital Cost ($M/AFY)	$13,538
	2060 O&M Cost ($/yr)	$23.8
	Capital Cost ($M)	$440
Long-Term Supply Reliability	Diversity of Supply Sources	Poor diversity
	Complexity of Transmission System	More Complex
	Complexity of Treatment	Average Complexity
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Poor phasing potential
	Ability to Meet Demands Beyond 2060	Average Opportunity
Timely Implementation and Certainty	Percent of Local Supply	0%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average Vulnerable
	Project development status in 2012	Some studies conducted and permitting process established[3]

Table 4.6 Portfolio 4 – Regional Option with Oklahoma City Raw Water[1]		
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	0%
Environmental Stewardship	Energy required for operation	Average energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Highly Likely
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	More impact[4]

Notes:

(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).

(2) All costs are in 2012 dollars (ENR 5416).

(3) Reflects status of bringing water from Southeast Oklahoma. There are uncertainties associated with water rights, however the process and treatment required is well understood.

(4) Reflects impacts to Norman resulting from building or expanding WTP versus using regional treatment facility proposed under Portfolio 3.

Table 4.7 Portfolio 5 – Regional Option with New Reservoir[1]		
Affordability[2]	Unit Capital Cost ($M/AFY)	$18,952
	2060 O&M Cost ($/yr)	$25.5
	Capital Cost ($M)	$620
Long-Term Supply Reliability	Diversity of Supply Sources	Poor Diversity
	Complexity of Transmission System	More Complex
	Complexity of Treatment	Average Complexity
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Poor phasing potential
	Ability to Meet Demands Beyond 2060	Good Opportunity
Timely Implementation and Certainty	Percent of Local Supply	0%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted, needs new reservoir[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	0%

Table 4.7 Portfolio 5 – Regional Option with New Reservoir[(1)]		
Environmental Stewardship	Energy required for operation	Average energy
	Permanent Environmental Impacts	More impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	More impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Reflects difficulty associated with developing new reservoir. Both Scissortail and Parker Reservoir sites have been evaluated but further study is necessary.

Table 4.8 Portfolio 6 – Regional Option with Kaw Lake[(1)]		
Affordability[(2)]	Unit Capital Cost ($M/AFY)	$19,155
	2060 O&M Cost ($/yr)	$25.7
	Capital Cost ($M)	$620
Long-Term Supply Reliability	Diversity of Supply Sources	Poor diversity
	Complexity of Transmission System	More complex
	Complexity of Treatment	Average complexity
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Poor phasing potential
	Ability to Meet Demands Beyond 2060	Poor opportunity
Timely Implementation and Certainty	Percent of Local Supply	0%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted and permitting process established[(3)]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	0%
Environmental Stewardship	Energy required for operation	Lower energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Possibly unlikely
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	More impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Reflects status of routing study between Kaw Lake and Norman.

4.2.4 Portfolio 7

Portfolio 7 is a variation of Portfolio 3. Portfolio 7 evaluates continued use of Lake Thunderbird, adds non-potable reuse, and expands conservation. The remainder of the 2060 supply needs is met through partnering with Oklahoma City for treated water.

Table 4.9 summarizes key attributes and a comparison of Portfolio 7 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio offers a more diverse supply portfolio than Portfolio 7, by combining multiple surface water sources along with a small amount of reclaimed water supplies. It draws upon a combination of local and regional sources. Because of the regional project that would need to be constructed at one time in order to gain benefit, phasing ability (to increase supplies incrementally as demands grow over time) is limited. Known permitting and water rights issues associated with bringing water from Southeast Oklahoma are similar to those described under Portfolios 3 and 4. Treatment complexity is moderate in comparison to other portfolios, consisting of continued water treatment for Lake Thunderbird, new (shared) treatment for Southeast Oklahoma water, and new treatment for reclaimed water.

This portfolio offers several advantages over Portfolio 3. It continues to use existing source (Lake Thunderbird) recognizing that NUA has already made capital investments in this development, transmission, and treatment of this source water. However, it does not continue use of the groundwater wells. It implements a NPR project as in recognition of the high value placed on the efficient use of water resources by the community.

Table 4.9 Portfolio 7 – Hybrid Portfolio with Oklahoma City Treated Water(1)

Affordability(2)	Unit Capital Cost ($M/AFY)	$9,712
	2060 O&M Cost ($/yr)	$21.7
	Capital Cost ($M)	$320
Long-Term Supply Reliability	Diversity of Supply Sources	Average diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	Average complexity
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Poor phasing potential
	Ability to Meet Demands Beyond 2060	Average opportunity
Timely Implementation and Certainty	Percent of Local Supply	25%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted and permitting process established(3)

Table 4.9 Portfolio 7 – Hybrid Portfolio with Oklahoma City Treated Water[1]		
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	3%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Highly likely
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	Average impact

Notes:

(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).

(2) All costs are in 2012 dollars (ENR 5416).

(3) Reflects understanding of bringing water from Southeast Oklahoma and non-potable reuse.

4.2.5 Portfolio 8

Portfolio 8 is a variation on Portfolios 1 and 2. Portfolio 8 implements augmentation to Lake Thunderbird, expands conservation and continues using water from Lake Thunderbird. The remainder of the 2060 supply needs is met through purchasing treated water from Oklahoma City (as wholesale customer).

Table 4.10 summarizes key attributes and a comparison of Portfolio 8 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio offers moderate diversity, by combining multiple surface water sources and reclaimed water (at higher rates than Portfolios 1, 2, and 7). Treatment complexity is relatively high because of the advanced treatment required for the Lake Thunderbird augmentation project. Similar to the description in Portfolio 1, Portfolio 8 is contingent on future regulations on IPR. Similar to Portfolio 2, it is anticipated that Norman will utilize the Take or Pay lower wholesale contract rate that result in use of more consistent water from Oklahoma City and peaking off other sources.

This portfolio continues use of Lake Thunderbird and discontinues use of the existing Garber-Wellington Aquifer wells. Portfolio 8 implements a high level of reuse, in recognition of community values. This portfolio offers a more balanced approach to being a wholesale customer of Oklahoma City than Portfolio 2.

Table 4.10 Portfolio 8 – Hybrid Portfolio with Lake Thunderbird Augmentation[1]		
Affordability[2]	Unit Capital Cost ($M/AFY)	$5,527
	2060 O&M Cost ($/yr)	$33.8
	Capital Cost ($M)	$180
Long-Term Supply Reliability	Diversity of Supply Sources	Average diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	More Complex
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Good Opportunity
	Ability to Meet Demands Beyond 2060	Average Opportunity
Timely Implementation and Certainty	Percent of Local Supply	82%
	Vulnerability to potential future changes in water rights allocations and water quality standards	More Vulnerable
	Project development status in 2012	Lack of existing regulations and/or no detailed studies[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	60%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of Lake Thunderbird Augmentation.

4.2.6 Portfolio 9

Portfolio 9 is a variation on Portfolio 1. In Portfolio 9, Lake Thunderbird continues to be used and groundwater use is significantly expanded through drilling of new wells. Additionally, conservation is expanded and a NPR project is implemented.

Table 4.11 summarizes key attributes and a comparison of Portfolio 9 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio has a good diversity through its use of surface water, groundwater, and reuse. Treatment complexity is above average, as all of these sources require different treatment processes. Portfolio 9 offers the best opportunity for phasing as new wells can be drilled and connected to the transmission network for treatment as additional supply is needed. This portfolio offers a high degree of local control over the management of Norman's supplies.

A concern with Portfolio 9 is the changing water quality in the Garber-Wellington Aquifer and concerns over long-term viability of the aquifer if pumped heavily for an extended period. Norman has historically used the existing wells for short periods of time, allowing the wells to recover for several months between use. Over the last few years, in order to remain within Lake Thunderbird allocation and minimize purchasing treated water from Oklahoma City, Norman has used the wells more frequently. As the wells are used more heavily, some wells have seen declining water quality. If this trend continues, the well field capacity may be reduced. Additionally, NUA chose to take some wells offline when the Arsenic Groundwater Rule was implemented, rather than implement wellhead treatment at affected wells. Depending on the standard for chromium-6 in anticipated future regulations, most of NUA's existing wells will likely require treatment. There is also a possibility that other constituents that are not currently regulated could be subject to future regulation, and that standards for existing regulated contaminants could be tightened.

Another concern with Portfolio 9 is the quantity of water in the aquifer. As is described in Chapter 3, OWRB is currently studying the Garber-Wellington Aquifer. While the study is not complete, it is anticipated that the permanent EPS for the wellfield will be reduced from the temporary 2.0 AFY per acre of dedicated land that is used for permitting wells in the aquifer. Preliminary analyses indicate that permit availability will not limit Norman's ability to withdraw water (Norman can allocate more land if needed to increase permitted withdrawal amount). However, a groundwater permit does not guarantee the ability to withdraw water. As has been seen recently in declining water quality, NUA has also seen local water levels decline after more heavy usage. NUA will need to manage wells through spacing new wells so as not to influence surrounding wells, along with rotating well usage.

Table 4.11 Portfolio 9 – Hybrid Portfolio Maximizing Groundwater Use(1)

Affordability(2)	Unit Capital Cost ($M/AFY)	$9,985
	2060 O&M Cost ($/yr)	$24.3
	Capital Cost ($M)	$330
Long-Term Supply Reliability	Diversity of Supply Sources	Good diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	More Complex
	Percent of Supply from Garber-Wellington Aquifer	75%
Phasing Potential	Ability to Phase Projects	Best Opportunity
	Ability to Meet Demands Beyond 2060	Average Opportunity
Timely Implementation and Certainty	Percent of Local Supply	100%
	Vulnerability to potential future changes in water rights allocations and water quality standards	More Vulnerable
	Project development status in 2012	Permitting process uncertain(3)
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	100%

Table 4.11 Portfolio 9 – Hybrid Portfolio Maximizing Groundwater Use(1)		
Environmental Stewardship	Energy required for operation	Lower energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Lower potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of chromium-6 MCL.

4.2.7 Portfolio 10

Portfolio 10 is a variation of Portfolio 5 and Portfolio 1. In Portfolio 10, Lake Thunderbird and existing groundwater wells (with treatment) continue to be used. Conservation is expanded and a non-potable reuse project is implemented. The balance of water supply needed to meet 2060 demands comes from a new Parker Reservoir.

Table 4.12 summarizes key attributes and a comparison of Portfolio 10 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio has a good diversity through its use of surface water, groundwater, and reuse. Treatment complexity is above average, as all of these sources require different treatment processes. Portfolio 10 offers water supply to meet needs beyond 2060. As described in Chapter 3, the capital cost for Parker Reservoir is based on meeting Norman's 2060 needs. Partnerships with other communities to share the reservoir's yield could reduce Norman's costs to develop this supply.

Portfolio 10 offers little opportunity for phasing, as the reservoir must be constructed at once. While Parker Reservoir has been studied, additional evaluation and detailed design and environmental assessment will need to be completed prior to implementation.

Table 4.12 Portfolio 10 – Hybrid Portfolio with Parker Reservoir(1)		
Affordability(2)	Unit Capital Cost ($M/AFY)	$14,996
	2060 O&M Cost ($/yr)	$24.7
	Capital Cost ($M)	$490
Long-Term Supply Reliability	Diversity of Supply Sources	Good diversity
	Complexity of Transmission System	More complex
	Complexity of Treatment	More complex
	Percent of Supply from Garber-Wellington Aquifer	30%
Phasing Potential	Ability to Phase Projects	Poor phasing opportunity
	Ability to Meet Demands Beyond 2060	Good Opportunity

Table 4.12 Portfolio 10 – Hybrid Portfolio with Parker Reservoir[1]		
Timely Implementation and Certainty	Percent of Local Supply	52%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted, needs new reservoir[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	3%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	More impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	More impact

Notes:

(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).

(2) All costs are in 2012 dollars (ENR 5416).

(3) Represents the current regulatory uncertainty of chromium-6 MCL and need for new reservoir.

4.2.8 Portfolio 11

In Portfolio 11, Lake Thunderbird and existing groundwater wells (with treatment) continue to be used. Conservation is expanded and a NPR project is implemented. The balance of water supply needed to meet 2060 demands comes from partnering with Oklahoma City for treated water. Portfolio 11 differs from Portfolio 2 because Norman would be a co-owner in raw water supply, transmission, and treatment with Oklahoma City instead of a wholesale customer to Oklahoma City as in Portfolio 2.

Table 4.13 summarizes key attributes and a comparison of Portfolio 11 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio offers a diverse supply portfolio combining surface, groundwater, and small amounts of reclaimed water supplies. Treatment complexity is average in that it requires continued water treatment for Lake Thunderbird, new treatment for Southeast Oklahoma water, new treatment for groundwater supplies, and new treatment for reclaimed water (though this treatment will be less complex and smaller quantities than that proposed for Lake Thunderbird augmentation). Similar to Portfolio 3, phasing opportunities are limited.

Table 4.13 Portfolio 11 – Hybrid Portfolio with Oklahoma City for Treated Water(1)		
Affordability(2)	Unit Capital Cost ($M/AFY)	$9,266
	2060 O&M Cost ($/yr)	$27.5
	Capital Cost ($M)	$300
Long-Term Supply Reliability	Diversity of Supply Sources	Good diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	Average complexity
	Percent of Supply from Garber-Wellington Aquifer	29%
Phasing Potential	Ability to Phase Projects	Average phasing potential
	Ability to Meet Demands Beyond 2060	Average Opportunity
Timely Implementation and Certainty	Percent of Local Supply	53%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted and permitting process established.(3)
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	3%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of chromium-6 MCL and status of bringing water from Southeast Oklahoma.

4.2.9 Portfolio 12

Portfolio 12 is similar Portfolio 10. In Portfolio 12, Lake Thunderbird continues to be used and conservation is expanded. A new Scissortail Reservoir provides the balance of water supply.

Table 4.14 summarizes key attributes and a comparison of Portfolio 12 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. This portfolio is less diverse than Portfolio 10 because it lacks both groundwater and reuse. It has low phasing potential, similar to Portfolio 10, because a new reservoir must be constructed. There have been more recent studies completed for the Scissortail Reservoir site than for Parker Reservoir, but detailed planning and environmental studies are still needed. Similar to Portfolio 10, there is the ability to access water supply to meet Norman's water needs beyond 2060.

Table 4.14 Portfolio 12 – Hybrid Portfolio with Scissortail Reservoir[1]		
Affordability[2]	Unit Capital Cost ($M/AFY)	$13,209
	2060 O&M Cost ($/yr)	$22.4
	Capital Cost ($M)	$430
Long-Term Supply Reliability	Diversity of Supply Sources	Poor diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	Average complexity
	Percent of Supply from Garber-Wellington Aquifer	0%
Phasing Potential	Ability to Phase Projects	Poor phasing potential
	Ability to Meet Demands Beyond 2060	Good Opportunity
Timely Implementation and Certainty	Percent of Local Supply	22%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted, needs new reservoir[3]
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	0%
Environmental Stewardship	Energy required for operation	Average energy
	Permanent Environmental Impacts	More impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Higher potential
Community Values	Impact on property rights	More impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Reflects difficulty associated with developing new reservoir.

4.2.10 Portfolio 13

Portfolio 13 is very similar to Portfolio 11, but differs in that Norman would collaborate with Oklahoma City for raw water supply and transmission, but treat the water at a NUA facility. In Portfolio 12, Lake Thunderbird and existing groundwater wells (with treatment) continue to be used. Conservation is expanded and a non-potable reuse project is implemented.

Table 4.15 summarizes key attributes and a comparison of Portfolio 13 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. The benefits and drawbacks are similar to those listed under

Portfolio 11 with a few exceptions. Portfolio 13 offers more local control and has higher treatment complexity because Norman is responsible for treating the water.

Table 4.15 Portfolio 13 – Hybrid Portfolio with Oklahoma City for Raw Water(1)		
Affordability(2)	Unit Capital Cost ($M/AFY)	$10,337
	2060 O&M Cost ($/yr)	$22.8
	Capital Cost ($M)	$340
Long-Term Supply Reliability	Diversity of Supply Sources	Good diversity
	Complexity of Transmission System	Average complexity
	Complexity of Treatment	More Complex
	Percent of Supply from Garber-Wellington Aquifer	29%
Phasing Potential	Ability to Phase Projects	Average phasing potential
	Ability to Meet Demands Beyond 2060	Average opportunity
Timely Implementation and Certainty	Percent of Local Supply	53%
	Vulnerability to potential future changes in water rights allocations and water quality standards	Average vulnerability
	Project development status in 2012	Some studies conducted and permitting process established(3)
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	3%
Environmental Stewardship	Energy required for operation	Higher energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of chromium-6 MCL and status of bringing water from Southeast Oklahoma.

4.2.11 Portfolio 14

Portfolio 14 is a variation of Portfolio 1. Portfolio 14 includes less water being sent to Lake Thunderbird for augmentation and recovery, and adds a few new groundwater wells. Portfolio 14 was added in response to input from AHC members suggesting that groundwater should continue to make up a similar proportion of Norman's 2060 supply as it does today.

Table 4.16 summarizes key attributes and a comparison of Portfolio 14 to other portfolios for some of the key evaluation criteria. The complete set of scores for this portfolio relative to all objectives and performance measures, as used in the evaluation and ranking process, is provided in Appendix B. The advantages and disadvantages are similar to Portfolio 1.

Table 4.16 Portfolio 14 – Hybrid Portfolio with New Wells and Lake Thunderbird Augmentation(1)

Affordability(2)	Unit Capital Cost ($M/AFY)	$8,326
	2060 O&M Cost ($/yr)	$21.7
	Capital Cost ($M)	$270
Long-Term Supply Reliability	Diversity of Supply Sources	Most Diverse
	Complexity of Transmission System	Least Complex
	Complexity of Treatment	More Complex
	Percent of Supply from Garber-Wellington Aquifer	36%
Phasing Potential	Ability to Phase Projects	Best Opportunity
	Ability to Meet Demands Beyond 2060	Good Opportunity
Timely Implementation and Certainty	Percent of Local Supply	100%
	Vulnerability to potential future changes in water rights allocations and water quality standards	More Vulnerable
	Project development status in 2012	Lack of existing regulations and/or no detailed studies (3)
Efficient Use of Water Resources	Percent of supply utilizing reclaimed wastewater (both NPR and IPR)	42%
Environmental Stewardship	Energy required for operation	Lower energy
	Permanent Environmental Impacts	Average impact
Treated Water Quality Aesthetics	Achieve secondary MCLs	Average likelihood
	Minimize taste and odor potential	Average potential
Community Values	Impact on property rights	Average impact

Notes:
(1) Representative evaluation of portfolio. Not all evaluation criteria are included in this table, but are available in Appendix B. Analysis is based on comparison between portfolios (for example, is Portfolio 1 more likely, less likely, or about the same as Portfolio 2 to have permanent environmental impacts).
(2) All costs are in 2012 dollars (ENR 5416).
(3) Represents the current regulatory uncertainty of Lake Thunderbird Augmentation and chromium-6 MCL.

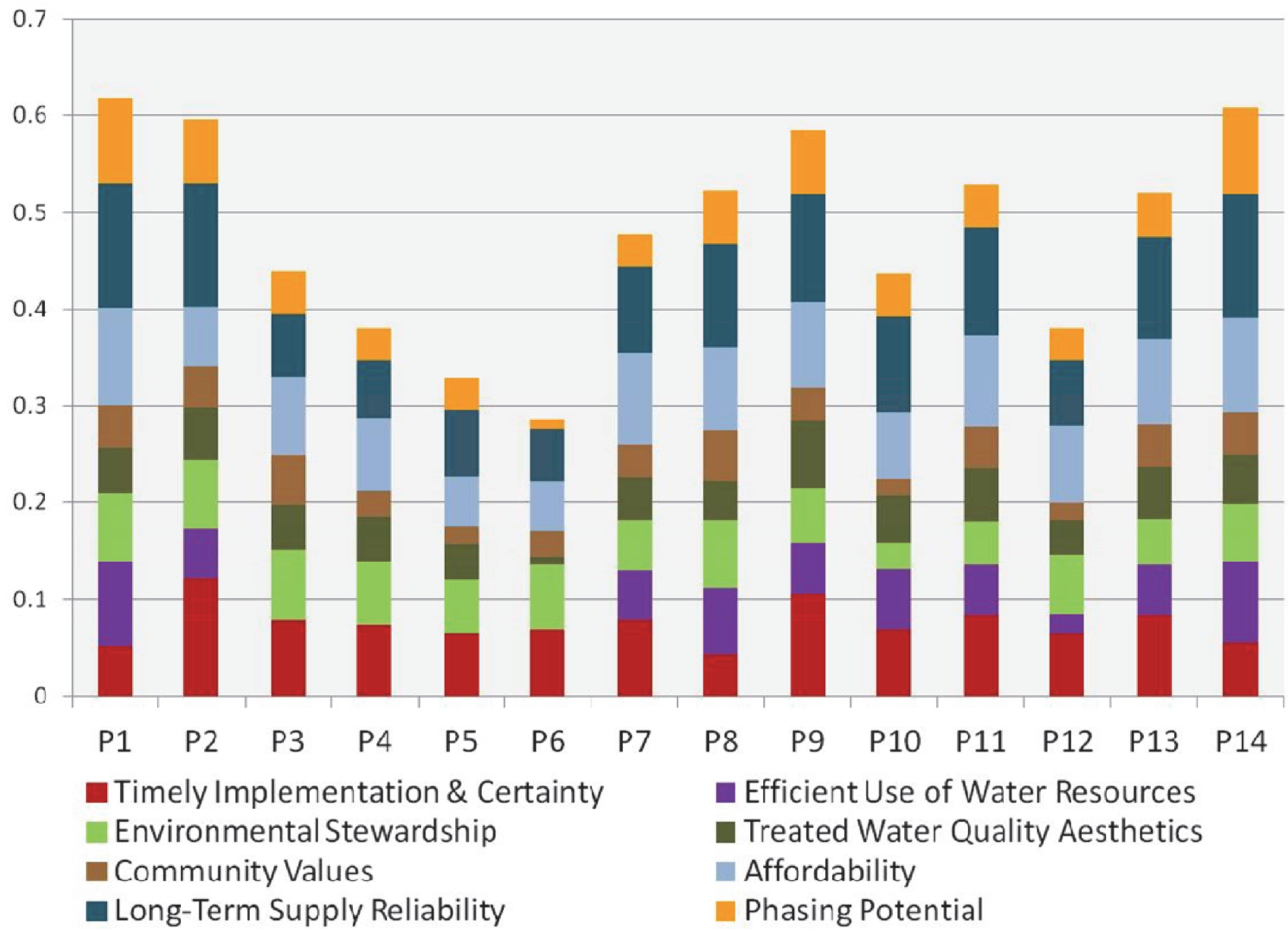
4.3 COMPARISON OF PORTFOLIOS

To compare the portfolios, raw scores were calculated or assigned for each objective and sub-objective, as listed in Section 4.1. The qualitative performance measures were rated on a scale of 1 to 5 and represent relative performance of a portfolio when compared to other portfolios. Quantitative measurements were calculated from data gathered for each portfolio. The raw score for each objective was then multiplied by the respective weighting to get a partial portfolio score. This process was repeated for each objective and for each portfolio utilizing commercially-available software designed for this purpose. Figure 4.2 illustrates the results of this analysis. A higher decision score indicates that the portfolio performed better against the most important objectives. Portfolios that meet a wide range of objectives well also were observed to score well in this analysis.

As expected, the single source portfolios, Portfolios 3, 4, 5, and 6, did not score well compared to other portfolios. These single source portfolios lack diversity, lack efficient water use (driven by conservation and use of treated water from the WRF), and lack local control and generally have longer transmission distances. All of these factors impact a wide variety of objectives negatively and result in lower scores. However, if these four portfolios are evaluated relative to each other, Portfolios 3 and 4, which focus on partnering with Oklahoma City for Southeast Oklahoma water, meet Norman’s long term needs better than Portfolio 5, which requires a new reservoir, and Portfolio 6, which uses Kaw Lake and has a longer transmission distance. Portfolios 5 and 6 have not been studied in as much detail as Southeast Oklahoma water supply options. Portfolios 3, 4, 5, and 6 were eliminated from further consideration.

Portfolios 10 and 12 have large new regional water supply components but also use local supplies to varying degrees. Portfolio 12 scores the lowest of these regional portfolios. It discontinues use of existing groundwater wells, lacks any reuse projects, and has significant risk associated with developing a new reservoir. Portfolio 10 includes continued use of already developed local water sources and new reclaimed water (improving its ability to meet Norman’s objectives over Portfolio 12) but still scores poorly because of the risk and expense associated with developing a new reservoir. Portfolios 10 and 12 were eliminated from further consideration.

Portfolios 2, 7, 11, and 13 involve partnering with Oklahoma City either through purchasing water as a wholesale customer or by becoming a co-owner in infrastructure for additional water supply. Portfolio 2 has low capital costs and scores well because of the diversity of supply sources. However, its annual operating costs are the highest of all of the portfolios. Additionally, Oklahoma City in recent discussions has indicated a preference that Norman participate in the Southeast Oklahoma supply project as a co-owner of the infrastructure (proportional to Norman’s use of the supply), rather than having Oklahoma City finance Norman’s debt for the infrastructure and recover those costs through its wholesale rates. Portfolios 7, 11, and 13 all utilize a co-owner approach for new Southeast Oklahoma water supply. The scores for Portfolios 11 and 13 are very similar. Portfolio 13 offers a little more local control because Norman would be responsible for treating raw water from Southeast Oklahoma. Portfolio 7 has the lowest overall score of this group. Portfolio 7 abandons groundwater wells (rather than treating the groundwater under anticipated regulatory requirements), lowering its score for long-term supply reliability and public acceptability. Portfolios 2, 7, and 11 were eliminated from further consideration. Portfolio 13 is among the three final recommended portfolios.



PORTFOLIO COMPARISON

FIGURE 4.2

NORMAN UTILITIES AUTHORITY
2060 STRATEGIC WATER SUPPLY PLAN

Portfolio 8 and 9 take opposite approaches to the use of groundwater. Portfolio 8 abandons all use of groundwater (including existing wells), while Portfolio 9 maximizes use of groundwater through drilling a large number of new wells. Feedback from the AHC and SWSP public meetings suggested that neither approach is practical or in Norman’s best interest. It is impractical to eliminate groundwater completely, as groundwater offers some degree of supply reliability through resistance to drought. However, as discussed in Chapter 3, there are concerns both about Garber-Wellington Aquifer quantity and quality, so it is impractical to rely to on groundwater as the vast majority of Norman’s supply. Portfolios 8 and 9 were eliminated from further consideration.

Portfolios 1 and 14 are fairly similar in terms of supply sources, as illustrated by their similar weighted decision scores. Both portfolios continue using existing sources, expand conservation, and have new reclaimed water projects, all of which are important to meeting Norman’s objectives. Portfolios 1 and 14 comprise the remaining two of the three recommended portfolios.

APPENDIX E

REUSE EVALUATION TECHNICAL MEMORANDUM

AIM NORMAN
AREA & INFRASTRUCTURE MASTER PLAN

REUSE EVALUATION TECHNICAL MEMORANDUM
DRAFT

CITY OF NORMAN AND NORMAN UTILITIES AUTHORITY

NORMAN, OKLAHOMA

AIM NORMAN
AREA & INFRASTRUCTURE MASTER PLAN

Prepared by:

Prepared by:

In Partnership with:

GARVER

RDG PLANNING • DESIGN

DRAFT
February 2025

Garver Project No. 22W02320
Norman Project No. WA0385

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List of Acronyms

Acronym	Definition
ADF	average daily flow
AIM	Area and Infrastructure Master
AOP	advanced oxidation process
BAF	biologically active filtration
BNR	biological nutrient removal
cBOD5	five-day carbonaceous biological oxygen demand
CFU	colony-forming unit
City	City of Norman
DPR	direct potable reuse
IPR	indirect potable reuse
MG	million gallons
MGD	million gallons per day
mg/L	milligrams per liter
MPN	most probable number
mUCT	modified University of Cape Town
NPV	net present value
NTU	nephelometric turbidity unit
NUA	Norman Utilities Authority
O&M	operation and maintenance
ODEQ	Oklahoma Department of Environmental Quality
OPCC	opinion of probable construction costs
RO	reverse osmosis
TDS	total dissolved solids
TM	technical memorandum
TOC	total organic carbon
TPC	total project cost
TSS	total suspended solids
UF	ultrafiltration
UV	ultraviolet
TDS	total dissolved solids
TPC	total project cost
WRF	water reclamation facility
WTP	water treatment plant

Executive Summary

The City of Norman (City) and the Norman Utilities Authority (NUA) are focused on sustainable water management. This Reuse Evaluation Technical Memorandum is part of a larger Area and Infrastructure (AIM Norman) Master Plan, detailing how reusing treated wastewater can meet the community's needs.

The main goals of this Reuse Evaluation TM are to:

1. **Review Indirect Potable Reuse (IPR) Alternatives and Implementation**: Explore the process, benefits, costs, and drawbacks of implementing IPR.
2. **Explore the Option of Direct Potable Reuse (DPR):** Explore the process, benefits, costs, and drawbacks of implementing DPR.
3. **Support Local Economy:** Provide a reliable alternative water source for residential, industrial, agricultural, and landscaping uses.

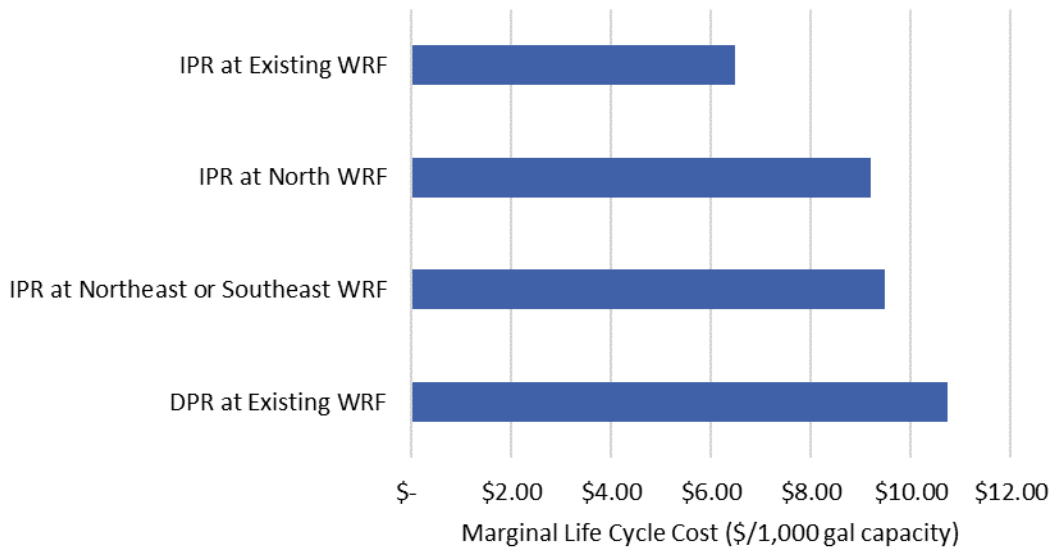
The Wastewater Treatment Evaluation TM determined that the whole NUA collection system is projected to produce an average daily flow (ADF) of 17.8 million gallons per day (MGD) of wastewater in the future, which includes a 10% reserve capacity.

This report examines implementing IPR either at the current water reclamation facility (WRF) or at a new site, while DPR is only considered for the present site due to limited flow in the catchment areas of a new WRF and the extra reuse losses associated with anticipated DPR treatment. The analysis concludes that adding a 5-10 MGD IPR system to the existing WRF offers the most cost-effective and technically viable path forward compared to other reuse options.

Figure ES-1 shows the marginal life cycle cost comparison of reuse alternatives, which suggest that adding IPR will carry a marginal life cycle cost of $6.47 per thousand gallons (kgal) of reuse water supply capacity. The intention of marginal life cycle costs is to provide a basis for comparing relative costs, not to capture all possible costs or serve as the basis for budgeting. Many of these costs would come in phases and will depend on the actual growth and flows experienced over time.

Figure ES-1: Marginal Life Cycle Cost Comparison of Reuse Alternatives

The marginal life cycle cost is determined by comparing the expected marginal costs of upgrading, operating, and maintaining WRF reuse processes, conveyance improvements, and water treatment plant (WTP) upgrades required by each alternative.



However, it should be noted that the unit cost presented is highly sensitive to the allocation of NUA's IPR effluent to offset NUA's withdrawals from Lake Thunderbird and is based on 100% allocation. The cost of IPR per unit of water supply will increase in proportion to the amount of NUA's IPR flow that is allocated in the future to other lake users, namely Midwest City and Del City.

If that allocation is favorable, incorporating IPR into the existing WRF would support long-term (20-year) wastewater treatment regulatory compliance and water supply sustainability for NUA, as well as set a precedent in the state that incentivizes reuse investment. The IPR system would treat wastewater to reuse standards established by the Oklahoma Department of Environmental Quality (ODEQ), giving NUA the potential to augment water levels in Lake Thunderbird and reduce reliance on external water sources.

If that allocation is unfavorable to NUA, DPR may become the lowest-cost reuse alternative. This would necessitate a multi-year endeavor to establish regulations, pilot data, and brine disposal options for DPR in Oklahoma, which would need to be initiated in advance of planning on DPR as a water supply.

In either case, NUA will continue to explore reuse as a supply alternative for Norman along with other more cost-efficient options.

1.0 INTRODUCTION

The City of Norman (City) and the Norman Utilities Authority (NUA) are dedicated to advancing sustainable water management practices to support the long-term viability of their water resources. This Reuse Evaluation Technical Memorandum (TM) is an integral component of the broader Area and Infrastructure Master Plan (AIM Norman), outlining strategies for the effective reuse of treated wastewater to support the community's water needs.

The key objectives of this Reuse Evaluation TM are to:

1. **Review Indirect Potable Reuse (IPR) Alternatives and Implementation:** Explore the process, benefits, costs, and drawbacks of implementing IPR.
2. **Explore the Option of Direct Potable Reuse (DPR):** Explore the process, benefits, costs, and drawbacks of implementing DPR.

This report is the culmination of thorough research, stakeholder engagement, and collaboration with industry experts. It reflects NUA's commitment to innovative water management solutions that balance the needs of the growing community with the imperative to protect and preserve natural resources. By embracing water reuse, Garver aims to support the resilience and sustainability of NUA's water infrastructure, securing future water for generations to come.

1.1 REUSE IN OKLAHOMA

For many years, NUA has evaluated the use of reclaimed water as a potential source. Additionally, they prompted the state to begin formulating regulatory criteria for IPR and carried out a comprehensive pilot study to demonstrate treatment efficacy and water quality. These efforts are foundational to the IPR design presented in this report.

At present, there are no regulations for DPR in Oklahoma. Establishing regulatory framework for DPR projects would likely be necessary before implementation, which could involve several years of pilot testing and regulatory discussions. The DPR design proposed here draws on experiences from previous projects in other states and follows a conservative approach, incorporating high-pressure reverse osmosis membranes as a physical barrier against pathogens, along with advanced oxidation processes to manage contaminants of emerging concern.

2.0 BASIS OF EVALUATION & PLANNING CRITERIA

Design criteria and regulatory requirements from a variety of sources were assembled to develop the evaluation criteria for analysis of the wastewater treatment system. Specifically, documents from the following sources were reviewed and referenced:

- ODEQ
- 10 States Standards
- City of Norman 2023 Engineering Design Criteria and Standard Specifications (Norman EDC)
- Water Environment Federation's Manual of Practice 8

2.1 REUSE

Recently established Oklahoma regulations for target IPR effluent water quality are shown in Table 2-1.

Table 2-1: Oklahoma IPR Effluent Water Quality Regulations (Oklahoma Administrative Code 252:628)

Parameter	Requirement	Sampling/Monitoring & Frequency
Adenovirus Type 15	5-log removal	Disinfection from secondary effluent to the end of pipe discharge
Salmonella typhimurium	5-log removal	
Cryptosporidium	3-log removal	
Giardia lamblia	3-log removal	
Total Coliform	<2 colony-forming unit (CFU) or most probably number (MPN)/100mL	Daily grab sample
Total Residual Chlorine	<0.1 milligrams per liter (mg/L) as Cl_2	Daily grab sample or online monitoring at the end of pipe discharge
5-Day Carbonaceous Biological Oxygen Demand ($cBOD_5$)	<5 mg/L	Daily maximum
pH	6.5 -9.0	Appendix A of Oklahoma Administrative Code § 252:606.
Flow	Monitored	Monitored continuously
Total Organic Carbon (TOC)	Monitored	Monitored continuously
Total Suspended Solids (TSS)	<5 mg/L	Daily maximum
Turbidity	2 NTU (daily average), 10 NTU (daily maximum), or 5 NTU (more that 5% of daily maximum per month)	Monitored continuously
Total Dissolved Solids (TDS)	<700 mg/L or 2 standard deviations above the mean background TDS value of the receiving water body	Monthly sampling

Parameter	Requirement	Sampling/Monitoring & Frequency
Chlorides Sulfates Aluminum Iron Manganese	"The calculated permit limits shall be applied as monthly average permit limits in the Oklahoma Pollutant Discharge Elimination System discharge permit. Daily maximum permit limits shall be established as 1.5 times the monthly average permit limits."	Monthly sampling
Total Nitrogen	8 mg/L (monthly average), 12 mg/L (daily maximum)	Weekly from May to October and twice a month from November to April.

Table 2-2 shows anticipated IPR Effluent water quality parameters from the 2023 IPR Pilot Study Final Report.

Table 2-2: IPR Pilot Report Anticipated IPR Effluent Water Quality

Parameter	Anticipated in IPR Discharge	Observed Practical Limits in Pilot
$cBOD_5$ (mg/L)	<2	2*
Total Coliform (CFU or MPN/100 mL)	<1	1*
TOC (mg/L as C)	<3	2
TSS (mg/L)	<3	2.5*
Turbidity (NTU)	<0.1	0.05
TDS (mg/L)	<500	400
Chlorides (mg/L)	<100	75
Sulfates (mg/L)	<125	75
Aluminum (mg/L)	<0.3	0.02*
Iron (mg/L)	<0.1	0.02*
Manganese (mg/L)	<0.05	0.002*
Total Nitrogen (mg/L as N)	<8	4
Total Phosphorus (mg/L as P)	<0.2	0.1

2.2 FLOW SPLIT

The City's topography includes four watersheds: the Canadian River, Little River, Rock Creek, and Dave Blue Creek watersheds. Force mains are required to unify these flows into a single water reclamation facility (WRF). All of these except the Canadian River drain to Lake Thunderbird, with a topographical divide roughly splitting NUA from northwest to southeast. A new WRF could simplify conveyance and eliminate the need to pump influent or effluent over this divide.

Based on discussion with NUA staff, a new WRF will receive wastewater influent from the Little River and Rock Creek drainages to the east/northeast of the divide while the existing WRF would handle the Canadian (west/southwest of divide) and Dave Blue Creek drainages. The Little River and Rock Creek converge in the Development Reserve area, providing a potentially strategic location for a new WRF or combined lift station. Watershed and projected land use modeling yields the flow splits shown in Table 2-3. For the purposes of this evaluation, all new WRF alternatives have been considered to have the same flow split regardless of WRF location. New WRFs are designed for 5 MGD average daily flow (ADF).

Table 2-3: Anticipated Flow Splits

Year	Little River ADF (MGD)	Rock Creek ADF (MGD)	New WRF ADF (MGD)	Canadian ADF (MGD)	Dave Blue Creek ADF (MGD)	Existing WRF ADF (MGD)	Total ADF (MGD)
2025	2.01	0.57	2.58	10.31	0.31	10.62	13.20
2026	2.08	0.62	2.70	10.35	0.37	10.73	13.43
2027	2.16	0.66	2.82	10.40	0.44	10.84	13.65
2028	2.23	0.71	2.94	10.44	0.50	10.94	13.88
2029	2.30	0.75	3.06	10.48	0.57	11.05	14.11
2030	2.38	0.80	3.18	10.53	0.63	11.16	14.33
2031	2.45	0.84	3.29	10.57	0.70	11.27	14.56
2032	2.52	0.89	3.41	10.61	0.76	11.37	14.79
2033	2.60	0.93	3.53	10.66	0.82	11.48	15.01
2034	2.67	0.98	3.65	10.70	0.89	11.59	15.24
2035	2.75	1.03	3.77	10.75	0.95	11.70	15.47
2036	2.82	1.07	3.89	10.79	1.02	11.81	15.69
2037	2.89	1.12	4.01	10.83	1.08	11.91	15.92
2038	2.97	1.16	4.13	10.88	1.15	12.02	16.15
2039	3.04	1.21	4.25	10.92	1.21	12.13	16.38
2040	3.11	1.25	4.37	10.96	1.27	12.24	16.60
2041	3.19	1.30	4.48	11.01	1.34	12.34	16.83
2042	3.26	1.34	4.60	11.05	1.40	12.45	17.06
2043	3.33	1.39	4.72	11.09	1.47	12.56	17.28
2044	3.40	1.43	4.84	11.14	1.53	12.67	17.51
2045	3.48	1.48	4.96	11.18	1.66	12.84	17.80

2.3 COST ESTIMATING CRITERIA

An opinion of probable construction costs (OPCC) was developed to allow NUA to compare the available alternatives on a monetary basis. In addition, life cycle costs were also developed to show the net present value (NPV) of the alternatives over a lifespan of 20-years when considering operation and maintenance (O&M) costs. The following items are used as a baseline for preparation of OPCCs:

- Actual cost estimates provided by equipment manufacturers and suppliers
- Previous cost estimates prepared by Garver
- Contractor bid tabulations from recent project deliveries

For most alternatives, costs are given as total project cost, which includes the OPCC as well as an additional 25% to cover the cost of professional engineering, bidding, and construction management services.

Table 2-4 provides the contingencies, mobilization costs, conveyance cost assumptions, contractor overhead and profit, and professional services costs assumed in the development of the estimated OPCCs and total project cost.

Table 2-4: Preliminary Cost Estimate Criteria

Consideration	Assumption
Contingency	30%
Conveyance Pipelines	$25/inch/foot
Conveyance Easements & Property Acquisition	10%
Mobilization	5%
Contractor Overhead and Profit	25%
Engineering, Bidding, & Construction Services	25%

The life cycle cost analysis is developed for a 20-year planning horizon and accounts for the flow and loading projections over that timeframe. The life cycle cost takes into account the OPCC of the alternative as well as the yearly O&M costs associated with operating the equipment. O&M costs include electricity, chemical costs, replacement of filter media and other components that have life spans of less than 20-years, and labor required for maintenance. When comparing alternatives, some common elements have not been included - for instance, the base O&M cost to treat wastewater to current permit limits have been excluded, since this cost will have to be paid regardless of where the treatment occurs. Marginal life cycle costs, however, have been included, such as the additional energy and personnel required to open a new facility or treat effluent to higher reuse standards. Table 3-7 presents the key assumptions made for the basis of the life cycle costs developed in this Technical Memorandum.

Table 2-5: Life Cycle Cost Parameters

Parameter	Value
Period	20 years
Assumed Inflation	5%
Assumed Interest Rate	5%
Power Cost	$0.10 kWh

3.0 INDIRECT POTABLE REUSE ALTERNATIVES

In line with NUA's long-term vision for its water resources and past investments in reuse exploration, this assessment considers potential IPR enhancements for plant alternatives, as well as DPR improvements for the current facility. IPR involves systems where reused water flows are passed through an environmental buffer—usually a natural water body—that dilutes them before they supply a drinking water facility. Given that cities generate wastewater, IPR serves as a dependable method for supplementing water supplies during droughts.

3.1 DESIGN INDIRECT POTABLE REUSE FLOW

The differences in expected flow to the current and new WRF, as outlined in Table 3-1, call for a distinction regarding reuse. While the potential demand for reuse water by 2045 could reach up to 10 MGD, the new WRF locations will not be able to meet this capacity. The existing WRF should produce 10 MGD, except on its lowest-flow days, provided all NUA flow continues to go to the existing WRF. Additionally, the flow splits presented in Table 3-5 reflect anticipated future influent, which includes a 10% reserve capacity for planning purposes. Conservative estimates of reliable IPR flow should exclude this reserve capacity. The IPR at the new WRF locations is designed and costed for a capacity of 5 MGD, while the existing WRF is designed for a capacity of 10 MGD.

In addition to WRF upgrades, a holistic evaluation of infrastructure required to add IPR capacity to the distribution system includes water treatment plant (WTP) capacity upgrades as well as O&M costs for that capacity. WTP capacity has been considered as 15 MGD for the 10 MGD existing WRF IPR option and 9 MGD for the 7.5 MGD new WRF option (because the 7.5 MGD already includes some cushion above likely use, which estimated at 6 MGD ADF - see Table 3-1). This allows peak withdrawal from the lake to be higher than average since IPR water could theoretically be "banked" in Lake Thunderbird, and the distribution system needs to be able to meet peak demand, not just average. Regulatory / legal outcomes remain uncertain at this time with regards to the relationship between the quantity of IPR water released to the lake and the increase in firm yield withdrawal allowed to NUA by Central Oklahoma Master Conservancy District and Oklahoma Water Resources Board.

For purposes of estimating O&M expenses, it is assumed here that reuse flows would generally track the projected average water supply gap, growing linearly over time toward the upper limit of the available reliable flow. These assumptions are shown in Table 3-1.

Table 3-1: Assumed IPR Flows Used for O&M Calculations

Scenario	2025 Projected Use (MGD)	2045 Projected Use (MGD)	Notes
Existing WRF IPR Flow	5	10	Driven by projected supply gap
New WRF IPR Flow	2.5	4	ADF limited

Where life cycle cost calculations refer to a "$/thousand gallons (kgal) capacity", capacity is calculated as the maximum realistically possible flows that could be produced by a given reuse scenario over a 20-year period, shown in Table 3-2. Flows are assumed to grow linearly between these values for simplicity's sake. It should be noted that these numbers are higher than the projected use in Table 3-1, reflecting the difference between ability and need.

Table 3-2: 20-yr IPR Capacity Potential Used for LCC Calculations

Scenario	2025 Production Capacity (MGD)	2045 Production Capacity (MGD)	20-yr Production Capacity (Acre-ft)	20-yr Production Capacity (M kgal)	Notes
Existing WRF IPR Flow	10	10	224,000	73.0	--
New WRF IPR Flow	2.5	4	72,800	23.7	ADF limited

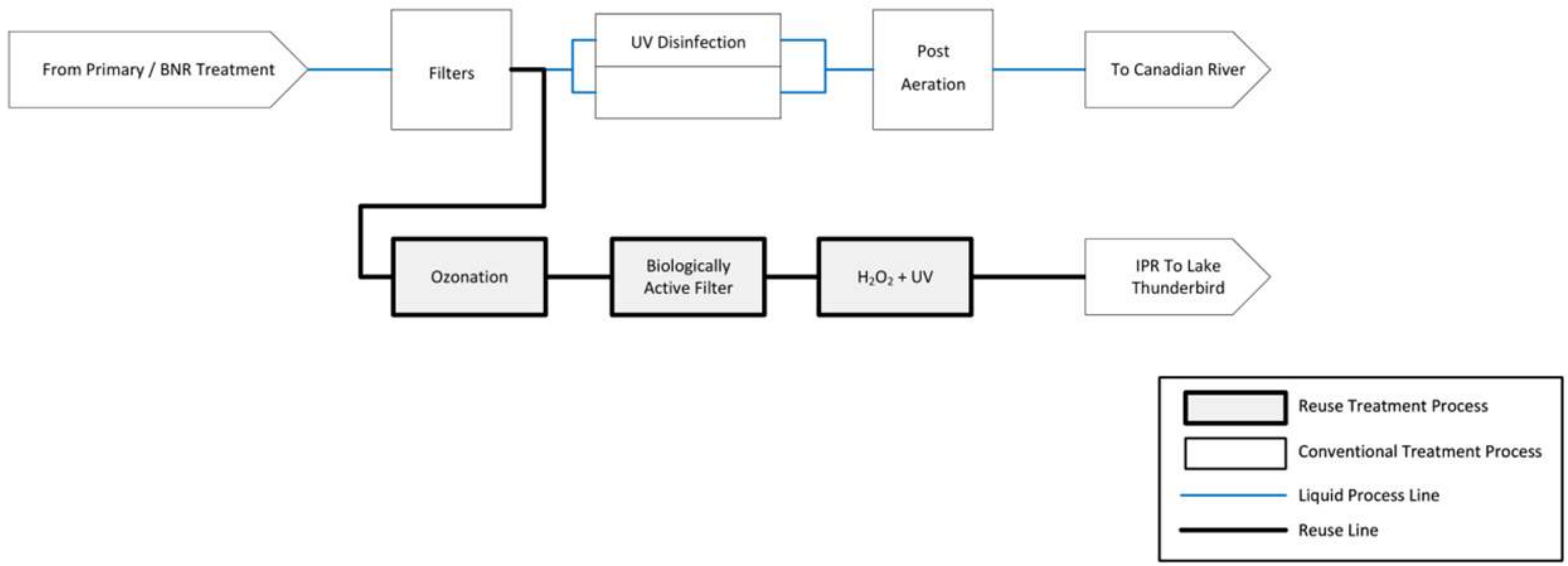
3.2 PROPOSED INDIRECT POTABLE REUSE TREATMENT PROCESS & LAYOUT

A simplified process flow diagram for IPR is shown in Figure 3-1. Filter effluent is redirected from the typical flow path and sent to:

- Ozonation
- Biologically active filtration (BAF)
- High-intensity ultraviolet (UV) disinfection with hydrogen peroxide, functioning as an advanced oxidation process (AOP)

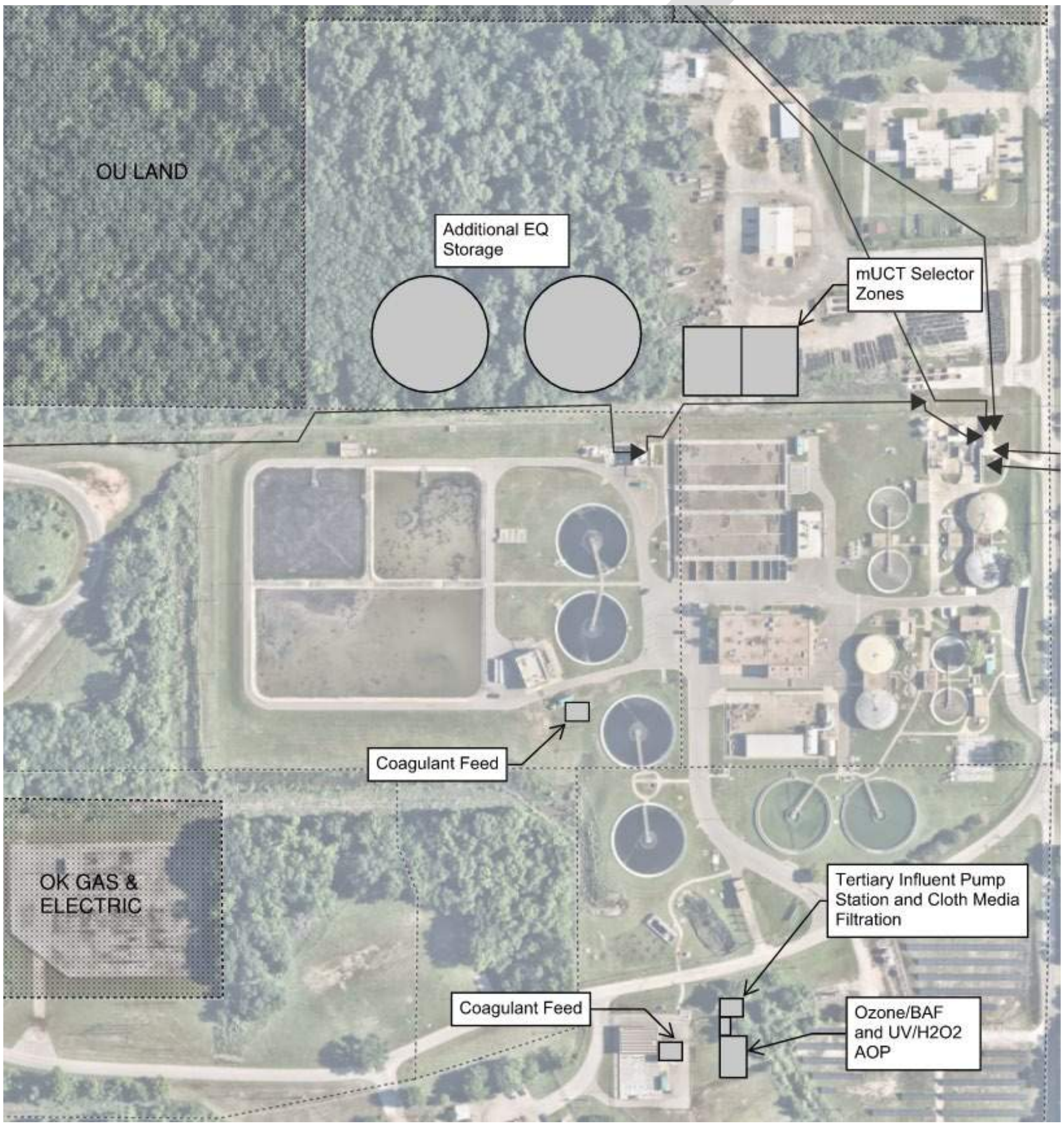
Finally, effluent is discharged to Lake Thunderbird. Ozonation provides strong oxidation to further disinfect and break down organic chemicals in the effluent, some of which are metabolized and further broken down by bacteria in the BAF. Ozone improves clarity, taste, and odor. The BAF also serves to further polish water turbidity. AOP UV provides a final step to both disinfect as well as further oxidize chemical compounds, such as contaminants of emerging concern.

Figure 3-1: Proposed Process Flow Diagram for IPR



Implementation of IPR at the existing WRF would follow the recommendations put forth in the recent IPR Pilot Report. The plant would need two major upgrades included in the design for the new WRF shown previously: modified University of Cape Town (mUCT) process trains (which would mean new tankage for the selector zones) and tertiary filtration (with coagulant feed upstream and downstream of the secondary clarifiers). Proposed locations for these upgrades, as well as the required ozone, BAF, and UV/AOP equipment, are shown Map 3-1.

Map 3-1: Proposed Site Layout for Building Out Existing WRF for 2045 Flows with IPR



3.2.1 CONVEYANCE IMPROVEMENTS

Conveyance improvements required to implement IPR at the existing WRF consist of additional conveyance from the Lake to the WTP and adding an effluent discharge pipeline running due east to the nearest sizeable tributary of Dave Blue Creek, shown in Map 3-2.

Map 3-2: Proposed IPR Effluent Pipeline from Existing WRF to Dave Blue Creek Tributary

3.2.2 TOTAL PROJECT COST

However, it should be noted that the unit cost presented is highly sensitive to the allocation of NUA's IPR effluent to offset NUA's withdrawals from Lake Thunderbird and is based on 100% allocation. The cost of IPR per unit of water supply will increase in proportion to the amount of NUA's IPR flow that is allocated in the future to other lake users, namely Midwest City and Del City.

If that allocation is favorable, incorporating IPR into the existing WRF would support long-term (20-year) wastewater treatment regulatory compliance (increasingly stringent permit limits) and water supply sustainability for NUA, as well as set a precedent in the state that incentivizes reuse investment. The IPR system would treat wastewater to reuse standards established by the Oklahoma Department of Environmental Quality (ODEQ), giving NUA the potential to augment water levels in Lake Thunderbird and reduce reliance on external water sources.

Total Project Cost (TPC) for 10 MGD IPR capacity at the existing plant is estimated at $154 million, plus a total of $61 million in conveyance improvements, shown in detail in Table 3-3 through Table 3-5.

Table 3-3: Existing WRF 10 MGD IPR Upgrades OPCC

Facility	OPCC	Total Project Cost
mUCT Upgrades	$43,781,000	$54,727,000
Tertiary Filtration	$13,619,000	$17,024,000
Ozonation	$28,389,000	$35,486,000
BAF	$22,188,000	$27,735,000
UV / AOP	$14,821,000	$18,527,000
Total	$122,799,000	$153,499,000

Table 3-4: IPR Upgrade OPCC for Conveyance of IPR water from Lake to WTP

Description	Design Flow (MGD)	Length (linear feet)	Diameter (inch)	Cost
Thunderbird to WTP Lift Station	7.5	--	--	$6,819,542
Thunderbird to WTP Force Main	15	43,180	36*	$6,477,000
*Unit costs is based on upsizing the existing 30-inch transmission main to a 36-inch				
Subtotal				$13,296,542
Contingency				$3,988,962
Professional Service - Design, Bidding, Construction Services				$3,324,135
Easements and Property Acquisition				$1,329,654
Total				**$21,939,294**

Table 3-5: IPR Upgrade OPCC for Conveyance of IPR Effluent to Nearest Lake Tributary from Existing WRF

Description	Design Flow (MGD)	Length (linear feet)	Diameter (inch)	Cost
Existing WRF to Dave Blue Creek Effluent Lift Station	10	--	--	$8,340,888
Existing WRF to Dave Blue Creek Effluent Force Main	10	20,395	30	$15,296,250
Subtotal				$23,637,138
Contingency				$7,091,141
Professional Service - Design, Bidding, Construction Services				$5,909,285
Easements and Property Acquisition				$2,363,714
Total				**$39,001,278**

Description	Design Flow (MGD)	Length (linear feet)	Diameter (inch)	Cost
Total with Lake to WTP Upgrade				$60,940,572

3.2.3 LIFE CYCLE COST

Capital costs outlined above are combined with O&M costs to arrive at a life cycle cost of $296 million for wastewater treatment and conveyance improvements, plus an additional $250 million in estimated life cycle costs for WTP capital improvements and O&M. This comes out to an overall unit life cycle cost of $7.47/kgal capacity, which makes it the least expensive reuse upgrade per kgal.

Table 3-6: Life Cycle Costs for Adding 10 MGD IPR at Existing WRF

Description	Cost
Reuse Plant TPC	$154M
Reuse Conveyance TPC*	$61M
Reuse O&M NPV	$8.1M
Reuse Marginal Life Cycle Cost	$223M
WTP TPC	$135M
WTP O&M NPV	$115M
WTP Marginal Life Cycle Cost	$250M
Total Marginal Life Cycle Cost	$473M
20-yr Production Capacity	73M kgal
Unit Life Cycle Cost	$6.47/kgal

3.3 INDIRECT POTABLE REUSE IMPLEMENTATION AT NEW WRF

A new WRF would be outfitted with IPR capacity sufficient for the entire plant flow, up to 7.5 MGD in the current planning horizon. Because any new WRF would be built with an mUCT process train and tertiary filtration already, IPR requires relatively fewer plant upgrades to implement than it would at the existing WRF. Only ozonation, BAF, and UV/AOP would need to be added. It also comes with a lower flow capacity, which could limit its usefulness as a water supply alternative.

3.3.1 CONVEYANCE IMPROVEMENTS

Conveyance improvements required to implement IPR at a new WRF consist of additional conveyance from Lake Thunderbird to the WTP and (for the NE/SE WRFs only) an effluent discharge pipeline described below.

3.3.2 TOTAL PROJECT COST

Adding 5 million gallons (MG) of IPR capacity to a new WRF is estimated to cost $53 million TPC, as broken down in Table 3-7.

Table 3-7: New WRF 5 MGD IPR Upgrades OPCC

Facility	OPCC	Total Project Cost
Ozonation	$18,494,000	$23,118,000
BAF	$16,641,000	$20,801,000
UV/AOP	$7,411,000	$9,263,000
Total	$42,546,000	$53,182,000

The OPCC for the pipeline from Lake Thunderbird to the WTP shown in Table 3-4 also applies to this alternative.

It is assumed that the North WRF site would not need additional conveyance to bring effluent to a Little River Tributary, as one is already onsite. However, the Northeast and Southeast WRF locations, as yet unfinalized, include an allowance for up to one mile of effluent pipeline included in their OPCC, as detailed in Table 3-8.

Table 3-8: IPR Upgrade OPCC for Conveyance of IPR effluent to Nearest Lake Tributary from NE/SE WRF

Description	Design Flow (MGD)	Length (linear feet)	Diameter (inch)	Cost
New WRF to Nearest Tributary Force Main	9	5,280	30	$3,960,000
Subtotal				$3,960,000
Contingency				$1,188,000
Professional Service - Design, Bidding, Construction Services				$990,000
Easements and Property Acquisition				$396,000
Total				**$6,534,000**
Total with WTP Conveyance				**$28,473,294**

3.3.3 LIFE CYCLE COST

Life cycle cost for adding 7.5 MGD of IPR at a new WRF is dependent on the location of the WRF, with the North WRF location coming in at a combined $317 million or $8.68/kgal and the Northeast and Southeast WRF sites both coming in at a combined $337 million or $9.23/kgal. While the total cost to implement these options is less in absolute terms, it would be added to a much more expensive new WRF and would yield a lower water supply capacity. See Table 3-9 for more details.

Table 3-9: Life Cycle Cost for Adding 7.5 MGD IPR at New WRF

Description	Cost	
	N WRF	NE/SE WRF
Reuse TPC	$53M	53M
Reuse Conveyance TPC	$22M	$28M
Reuse O&M NPV	$12.1M	$12.1M
Reuse Marginal Life Cycle Cost	$87M	$94M
WTP TPC	$81M	$81M
WTP O&M NPV	$50M	$50M
WTP Marginal Life Cycle Cost	$131M	$131M
Total Marginal Life Cycle Cost	$218M	$225M
20-yr Production Capacity	24M kgal	24M kgal
Unit Life Cycle Cost	$9.19/kgal	$9.47/kgal

4.0 DIRECT POTABLE REUSE ALTERNATIVES

DPR involves sending highly treated wastewater directly to a drinking water facility without passing it through an environmental buffer. DPR includes extra treatment like ultrafiltration (UF) and reverse osmosis (RO) membranes to address the lack of natural dilution, which increases costs beyond that of IPR. Despite the higher expenses, DPR offers the advantage of providing water supply without needing approval from Lake Thunderbird stakeholders. Challenges include managing RO brine disposal and the absence of existing DPR regulations in Oklahoma, which could require lengthy piloting and approval processes.

4.1 DESIGN DIRECT POTABLE REUSE FLOW

As discussed in Section 3.1, flows at the existing WRF vs new WRF cannot be expected to be equal. This difference is exacerbated by DPR, which loses a significant portion of flow (~20%) as RO reject. It was decided during the course of this evaluation that the additional complication and expense of DPR would not be worthwhile at a new WRF but would be best evaluated as an optional upgrade for the existing WRF only.

The upgrades to the WTP for DPR are somewhat modest because DPR lacks the capability to store water for peak demand unless a substantial terminal storage basin is constructed, which is not part of the proposed plan. For purposes of estimating O&M expenses, it is again assumed that reuse flows would generally track the projected average water supply gap, growing linearly over time toward the upper limit of the available reliable flow. These assumptions are shown in Table 4-1.

Table 4-1: Assumed DPR Flows Used for O&M Calculations

Projected Use	MGD	Notes
2025 DPR Flow:	5	Driven by projected supply gap
2045 DPR Flow:	10	Driven by projected supply gap

Where life cycle cost calculations refer to a "$/kgal capacity", capacity is calculated as the maximum realistically possible flows that could be produced by a given reuse scenario over a 20-year period, shown in Table 4-2 and Table 4-3. Flows are assumed to grow linearly between these values for simplicity's sake.

Table 4-2: Capacity Potential Flows Used for Life Cycle Cost Calculations

Capacity Potential	MGD	Notes
2025 DPR Flow:	9.45	11.8 MGD ADF * 80% Recovery
2045 DPR Flow:	10.0	--

Table 4-3: 20-yr DPR Capacity Potential Used for LCC Calculations

Scenario	2025 Production Capacity (MGD)	2045 Production Capacity (MGD)	20-yr Production Capacity (Acre-ft)	20-yr Production Capacity (M kgal)	Notes
DPR	10	10	218,000	71.0	--

4.2 PROPOSED DIRECT POTABLE REUSE TREATMENT PROCESS & LAYOUT

DPR for NUA is recommended to include three main elements: UF membranes, RO membranes, and high-energy UV/AOP. Ultrafiltration membranes remove fine suspended solids and protect the RO membranes from fouling as easily. RO membranes allow only small molecules to pass through, catching most dissolved or suspended compounds from the water as well as virtually all larger compounds, viruses, and bacteria. The pressure required to force water through such a fine membrane is usually above 100 pounds per square inch, none of which is recovered. Hence RO consumes a significant amount of electricity compared to other processes. RO filtrate passes through the membranes, but a minority of the flow concentrates the impurities and is discharged as concentrate, also known as reject or brine.

Inland brine disposal consists of three main options:

- Dilution into non-reuse effluent
- Drying beds
- Deep well injection

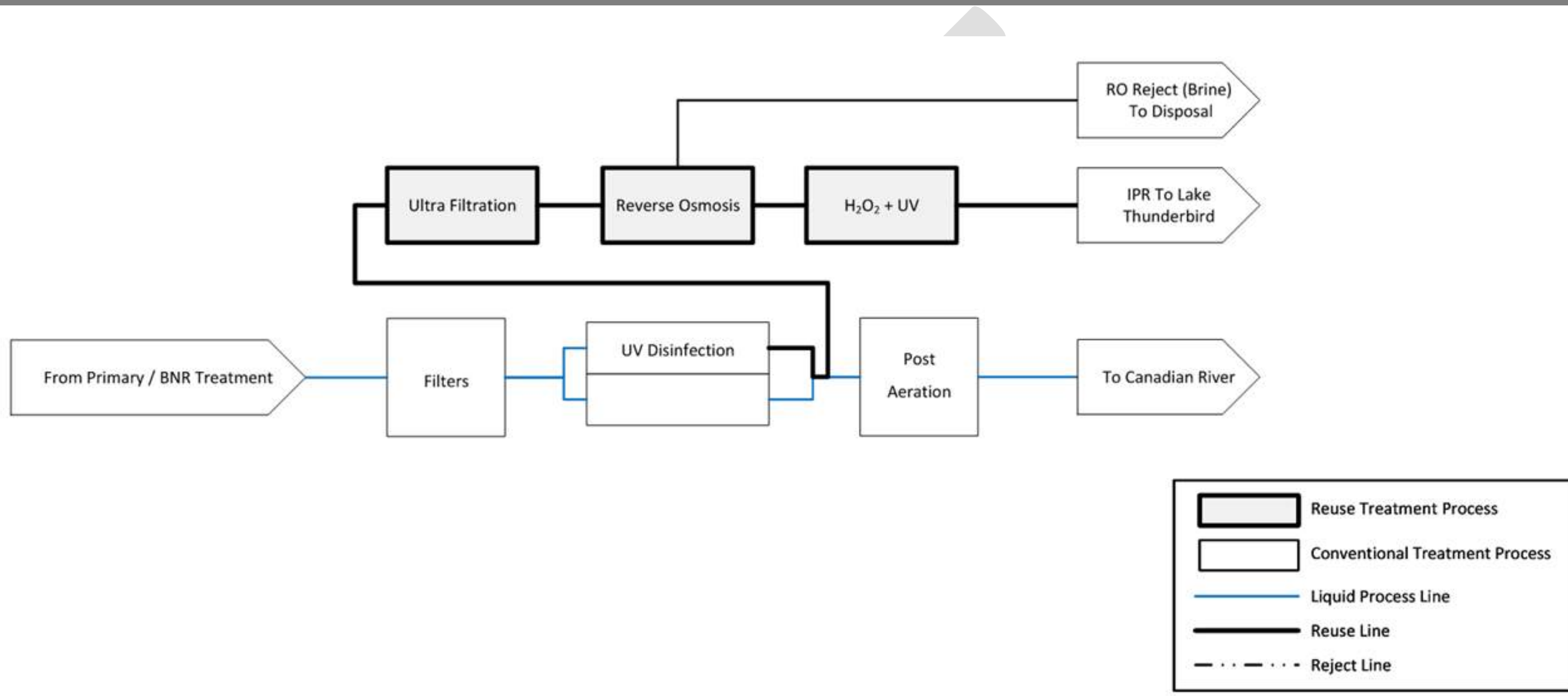
First, brine may be diluted back into the Canadian effluent stream if permitting allows. It is unknown whether this would be approved. This approach would introduce a concentrated stream of undesirable chemicals and salts to the river. If possible, it would likely be limited by TDS, in which case the combined plant effluent should not exceed receiving stream TDS, which is often near 800 mg/L or below. Plant effluent, according to the IPR Pilot Report, hovers around 400 mg/L, meaning the plant would need roughly half its flow to continue going to the Canadian River just to provide dilution water. This would limit the ability of the plant to produce reuse water for consumption.

Second, drying beds could in theory dry RO concentrate. However, the potential reject stream is 2 MGD, requiring a large acreage dedicated to drying this reject. Worse, for much of the year precipitation exceeds evaporation. Drying beds do not appear feasible for NUA.

Lastly, deep well injection could be implemented if the geology proves favorable. Impurities and salts would be injected with the brine stream into a permeable geological layer determined to be hydraulically isolated from usable groundwater above. Geologically suitable locations are not guaranteed to be found nearby, and may require extensive exploration, pipelines, and potentially injections pumps. This option is assumed for the purposes of this evaluation.

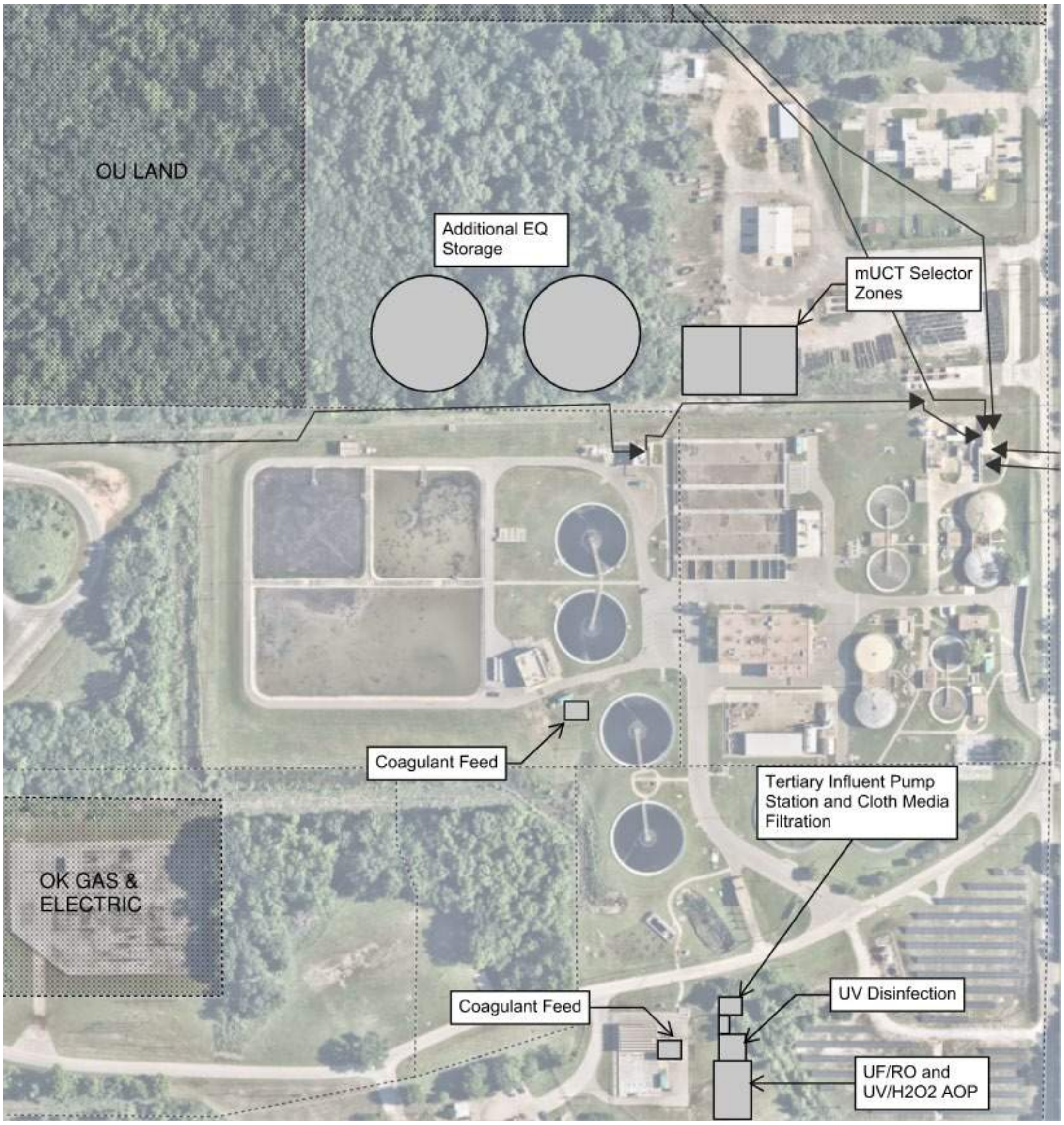
A simplified process flow diagram is shown in Figure 4-1.

Figure 4-1: Proposed DPR Process Flow Diagram



The proposed site layout (see Map 4-1) resembles the site layout for IPR at the existing WRF, but with a larger building required for UF/RO and UV/AOP than IPR's Ozone and UV/AOP.

Map 4-1: Proposed 10 MGD DPR Site Layout

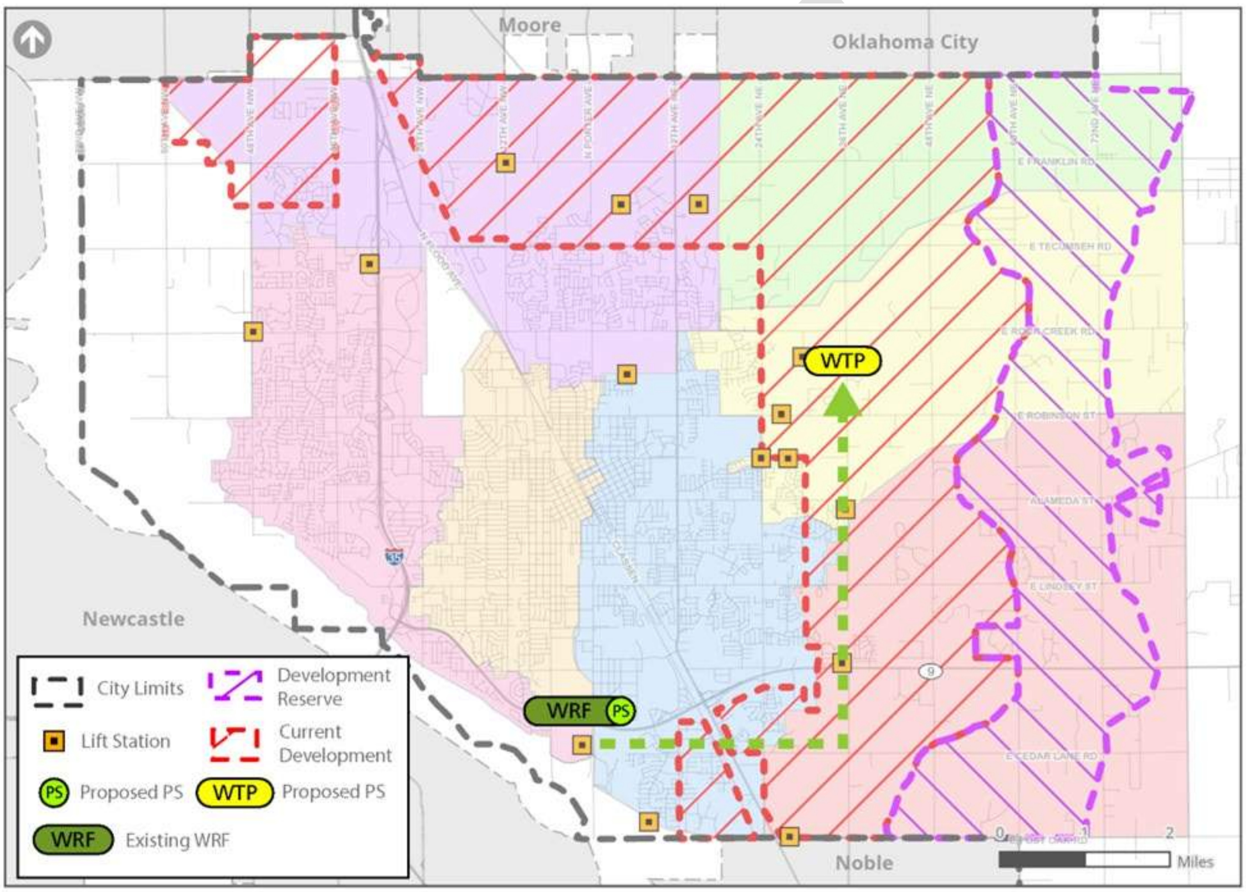


IPR, by its nature, provides a large buffering and storage capacity, both in terms of dilution as well as withdrawal vs replenishment rates. DPR does not. Garver recommends 5 MG of storage to be able to smooth effluent pumping between shifts in WRF output and WTP demand. A 5 MG elevated pre-stressed concrete tank has been included in in the design, assumed to be placed near the WTP. Additional DPR storage near the WTP may be possible but is unlikely to provide benefit beyond seasonal storage capacity.

4.3 CONVEYANCE IMPROVEMENTS

Conveyance improvements for DPR at the existing WRF consist mainly of a pipeline routing the DPR effluent to the WTP directly. This is proposed to run east from the WRF before following 36th Avenue East north to the WTP, as shown in Map 4-2.

Map 4-2: DPR Effluent Pipeline from Existing WRF to WTP



However, due to the complexity of the DPR process, it is recommended that similar lake conveyance and treatment plant upgrades as included for IPR (e.g., 15 MGD capacity) be included for DPR. This would allow the WTP to continue treating the needed flow rate if DPR needs to shut down for some reason, as well as allowing for peak demand withdrawal that DPR is unable to provide.

4.4 TOTAL PROJECT COST

The estimated TPC to implement DPR at the NUA WRF is $412 million. This price includes mUCT upgrades and tertiary filtration, a UF/RO building, UV/AOP and Chemical buildings, an assumed five miles pipeline to a suitable deep well injection facility, as well as a buffering tank as discussed above. Site civil and electrical have also been included. See Table 4-4.

Table 4-4: Existing WRF 10 MGD DPR Upgrades OPCC/TPC

Facility	10 MGD OPCC	10 MGD Total Project Cost
mUCT Upgrades	$43,781,000	$54,727,000
Tertiary Filtration	$13,619,000	$17,024,000
Site Civil	$30,736,000	$38,419,000
5 MG Storage Tank	$10,027,000	$12,534,000
UF/RO Building	$117,600,000	$147,000,000
Chemical Building	$17,273,000	$21,591,000
UV/AOP	$26,551,000	$33,189,000
Brine Disposal Pipeline (5 miles)	$16,979,000	$21,223,000
Brine Disposal Deep Well Injection Site	$16,474,000	$20,592,000
Site Electrical, Instrumentation, and SCADA	$36,883,000	$46,103,000
Total	**$329,922,000**	**$412,403,000**

Table 4-5 shows the projected cost for the pipeline from the WRF to the WTP, unique to DPR. DPR total conveyance costs also include the upsized pipe replacement from the lake the WTP to meet peak demand needs since DPR is not able to provide peak flows.

Table 4-5: DPR Upgrade TPC for Conveyance of from Existing WRF to WTP

Description	Design Flow (MGD)	Length (linear feet)	Diameter (inch)	Cost
Existing WRF to Existing WTP - WRF Lift Station	10	--	--	$8,340,888
Existing WRF to Existing WTP Force Main	10	39,295	30	$29,471,250
Subtotal				$37,812,138
Contingency				$11,343,641
Professional Service - Design, Bidding, Construction Services				$9,453,035
Easements and Property Acquisition				$3,781,214
Total				**$62,390,028**
Total with Lake-WTP Upgrades				**$84,329,322**

4.5 LIFE CYCLE COST

The life cycle cost for DPR is higher than that for IPR options, as anticipated. The combined TPC for the reuse system, including the treatment and conveyance components, is estimated at $715 million, resulting in a unit cost of $10.31 per kgal of capacity. This is detailed in Table 4-6, which outlines the key cost components for adding a 10 MGD DPR system at the existing WRF including conveyance, O&M costs, and costs associated with expanding the WTP.

Table 4-6: Life Cycle Cost for Adding 10 MGD DPR at Existing WRF

Description	Cost
Reuse TPC	$412M
Reuse Conveyance TPC	$84M
Reuse O&M NPV	$14.5M
Reuse Marginal Life Cycle Cost	$511M
WTP TPC	$135M
WTP O&M NPV	$115M
WTP Marginal Life Cycle Cost	$250M
Total Marginal Life Cycle Cost	$761M
20-yr Production Capacity	71M kgal
Unit Life Cycle Cost	$10.72/kgal

5.0 CONCLUSIONS

If reuse is pursued as an avenue for expanding NUA's portfolio of water supply options, Garver recommends adding IPR at the existing plant as the least expensive and least technically complex option explored. This is in alignment with the recommendations of the IPR Pilot Report. IPR and DPR as potential water supply alternatives will be evaluated in further detail in their respective portions of the Water Supply Alternatives Evaluation of this Master Plan. Table 5-1 summarizes reuse alternative life cycle costs.

Table 5-1: Marginal Life Cycle Cost Comparison of Reuse Alternatives

Description	Reuse Marginal Life Cycle Cost	WTP Marginal Life Cycle Cost	Total Marginal Life Cycle Cost	20-yr Reuse Capacity	Capacity Cost
Existing WRF + IPR	$223M	$250M	$473M	73.0M kgal	$6.48/kgal
Existing WRF + DPR	$511M	$250M	$761M	71.0M kgal	$10.72/kgal
North WRF + IPR	$87M	$131M	$218M	23.7M kgal	$9.19/kgal
NE or SE WRF + IPR	$94M	$131M	$225M	23.7M kgal	$9.47/kgal

APPENDIX F

WATER SUPPLY ALTERNATIVES COST ESTIMATES

Stormwater Capture		
Anticipated Capacity (2060 Strategic Water Supply Plan) (MGD)	5.8	
Project Cost (2060 Strategic Water Supply Plan)	$	1,220,000,000
August 2014 - 2023 Construction Cost Index	$	1.4
Total Project Cost	$	1,708,000,000

Parker Reservoir		
Anticipated Capacity (2060 Strategic Water Supply Plan) (MGD)	29.1	
Pipeline (75 miles of 30-inch)	$	490,050,000
Conventional Treatment w/ Softening (29.1 MGD)	$	261,900,000
2 Pump Stations (29.1 MGD)	$	35,235,000
Terminal Storage Reservoir (5,900 AF per 2060 Strategic Water Supply Plan)	$	31,710,000
Parker Reservoir	$	104,000,000
Total Project Cost	$	922,895,000

Scissortail Reservoir		
Anticipated Capacity (2060 Strategic Water Supply Plan) (MGD)	19.9	
Pipeline (60 miles of 30-inch)	$	392,040,000
Conventional Treatment w/ Softening (19.9 MGD)	$	179,100,000
2 Pump Stations (19.9 MGD)	$	27,005,000
Terminal Storage Reservoir (4,200 AF per 2060 Strategic Water Supply Plan)	$	31,710,000
Scissortail Reservoir	$	126,667,000
Total Project Cost	$	756,522,000

Thunderbird Spillage		
Anticipated Capacity (2060 Strategic Water Supply Plan) (MGD)	5.8	
Project Cost (2060 Strategic Water Supply Plan)	$	510,000,000
August 2014 - 2023 Construction Cost Index	$	1.4
Total Project Cost	$	714,000,000

New In-Basin Reservoir		
Anticipated Capacity (2060 Strategic Water Supply Plan) (MGD)	5.8	
Pipeline (15 miles of 36-inch)	$	117,612,000
Pump Station (15 MGD peak conveyance)	$	11,079,000
Reservoir (75,000 AF per 2060 Strategic Water Supply Plan Thunderbird Spillage)	$	566,250,000
Total Project Cost	$	694,941,000

DPR		
Anticipated Capacity (average) (MGD)	10.0	
Pipeline from WRF to WTP (7 miles of 30-inch)	$	48,628,000
Pump Station (10 MGD)	$	13,763,000
Pipeline from Lake Thunderbird to WTP (8 miles of 36-inch)[1]	$	10,688,000
Pump Station (15 MGD peak conveyance)[1]	$	11,253,000
Raw Water Source Storage (10 MGD)	$	590,000
WTP Upgrades (15 MGD peak)	$	135,000,000
WRF Upgrades	$	412,000,000
Total Project Cost	$	631,922,000

[1]Marginal cost of upsizing existing infrastructure

IPR - Existing WRF		
Anticipated Capacity (MGD)	10.0	
Pipeline from WRF to nearest tributary (4 miles of 30-inch)	$	25,239,000
Pump Station (10 MGD)	$	13,763,000
Pipeline from Lake Thunderbird to WTP (8 miles of 36-inch)[1]	$	10,688,000
Pump Station (15 MGD peak conveyance)[1]	$	11,253,000
Intake Structure (15 MGD)	$	885,000
WTP Upgrades (15 MGD)	$	135,000,000
WWTP Upgrades	$	154,000,000
Total Project Cost	$	350,828,000

[1]Marginal cost of upsizing existing infrastructure

IPR - North WRF		
Anticipated Capacity (MGD)	5.0	
Pipeline from Lake Thunderbird to WTP (8 miles of 36-inch)[1]	$	10,688,000
Pump Station (15 MGD peak conveyance)[1]	$	11,253,000
Intake Structure (10 MGD)	$	590,000
WTP Upgrades (15 MGD)	$	81,000,000
WWTP Upgrades	$	53,200,000
Total Project Cost	$	156,731,000

[1]Marginal cost of upsizing existing infrastructure

IPR - NE or SE WRF		
Anticipated Capacity (MGD)	5.0	
Pipeline from WRF to nearest tributary (1 mile of 30-inch)	$	6,534,000
Pipeline from Lake Thunderbird to WTP (8 miles of 36-inch)[1]	$	10,688,000
Pump Station (15 MGD peak conveyance)[1]	$	11,253,000
Intake Structure (10 MGD)	$	590,000
WTP Upgrades (15 MGD)	$	81,000,000
WWTP Upgrades	$	53,200,000
Total Project Cost	$	163,265,000

[1]Marginal cost of upsizing existing infrastructure

Canadian River - Alluvium Wells		
Anticipated Capacity (MGD)		10.0
Pipeline from WRF to nearest tributary (15 miles of 16-inch)	$	53,666,000
Pump Station (15 MGD)	$	18,280,000
24 New Wells	$	30,096,000
Treatment	$	153,625,000
Total Project Cost	$	255,667,000

GW New Wells: Disinfection Only		
Anticipated Capacity (MGD)	5.0	
Pipeline (3 miles of 20-inch, 4 miles of 16-inch, 3 miles of 12-inch)	$	34,848,000
20 New Wells	$	33,000,000
Total Project Cost	$	67,848,000

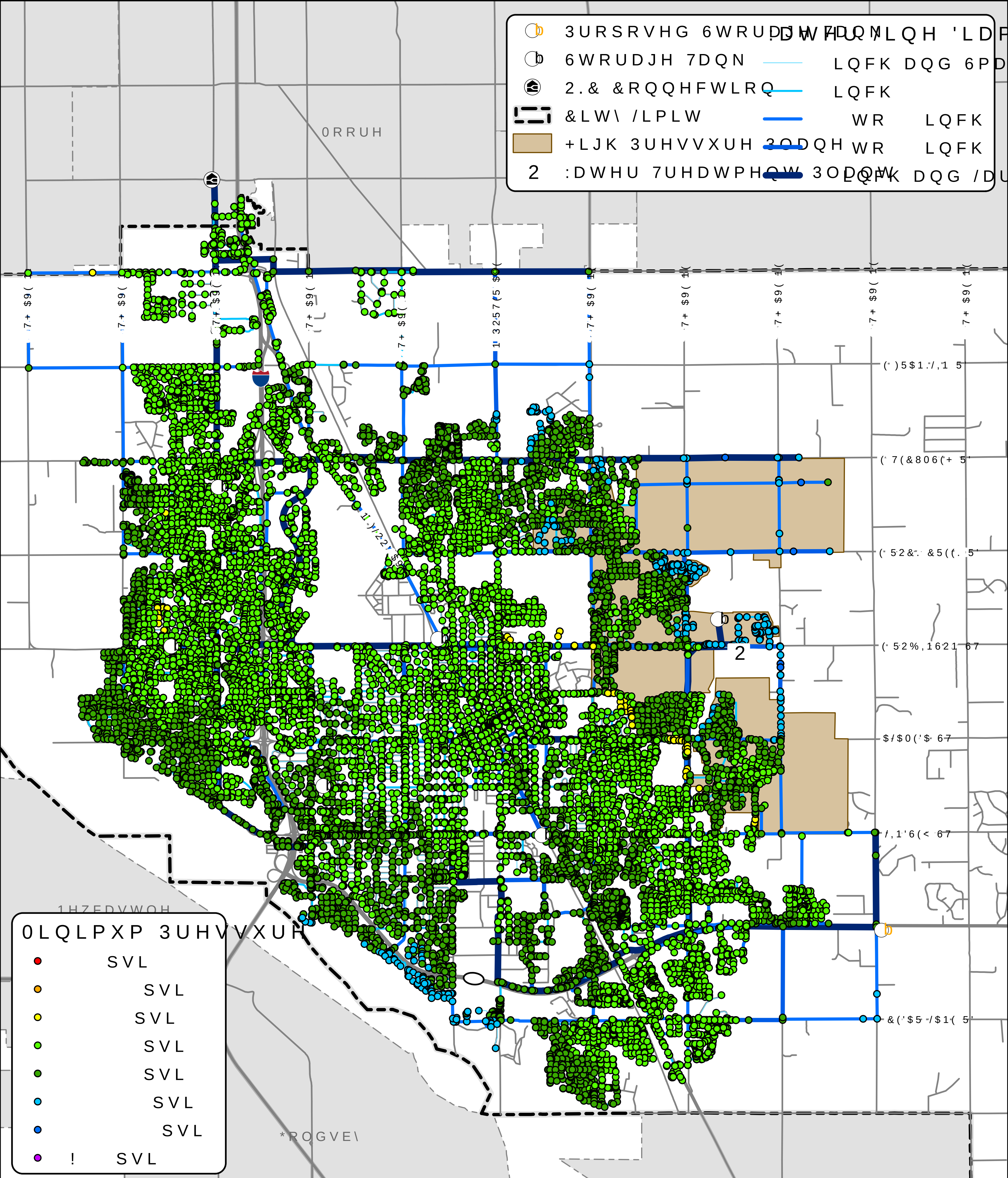
GW New + Inactive Wells: With Treatment		
Total Anticipated Capacity(Inactive Wells + New Wells) (MGD)		5.3
Anticipated Capacity of Inactive Wells (2060 Strategic Water Supply Plan) (MGD)		1.6
Treatment	$	13,041,000
Pipeline to connect inactive wells to active well network (15 miles of 12-inch)	$	39,779,000
Anticipated Capacity of New Wells (MGD)		3.8
Treatment	$	10,575,000
Pipeline (2.5 miles of 20-inch, 2.5 miles of 16-inch, 2.5 miles of 12-inch)	$	26,136,000
15 New Wells	$	24,750,000
Total Project Cost	$	114,281,000

GW New Wells: With Treatment	
Anticipated Capacity (MGD)	5.0
Treatment	$ 8,460,000
Pipeline (3 miles of 20-inch, 4 miles of 16-inch, 3 miles of 12-inch)	$ 34,848,000
20 New Wells	$ 33,000,000
Total Project Cost	$ 76,308,000

Oklahoma City Wholesale		
Anticipated Capacity (MGD)		6.0
Project Cost (2060 Strategic Water Supply Plan)	$	14,100,000
August 2014 - 2023 Construction Cost Index	$	1.4
Total Project Cost	$	19,130,000

APPENDIX G

FUTURE HORIZONS HYDRAULIC MODEL RESULTS



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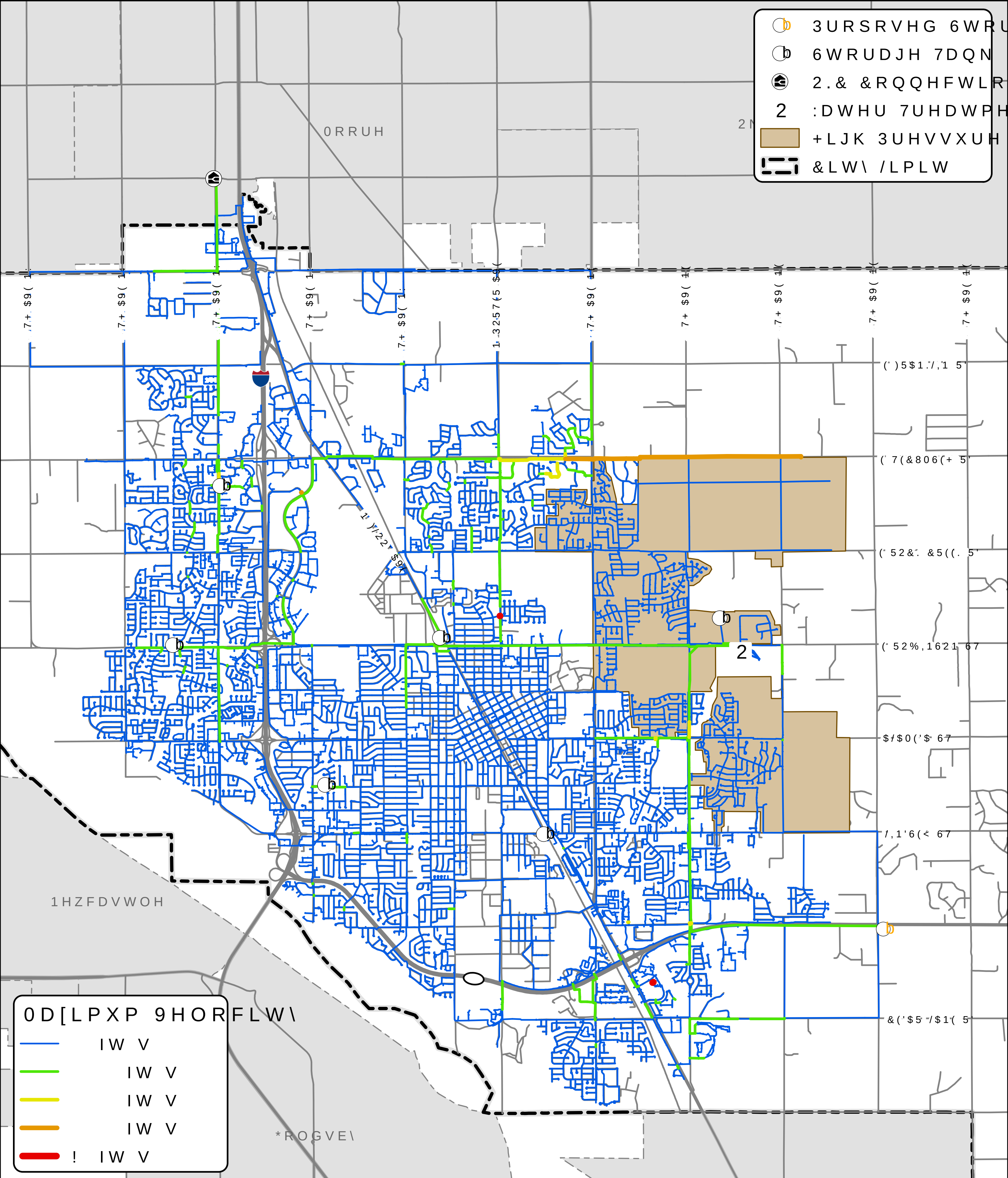

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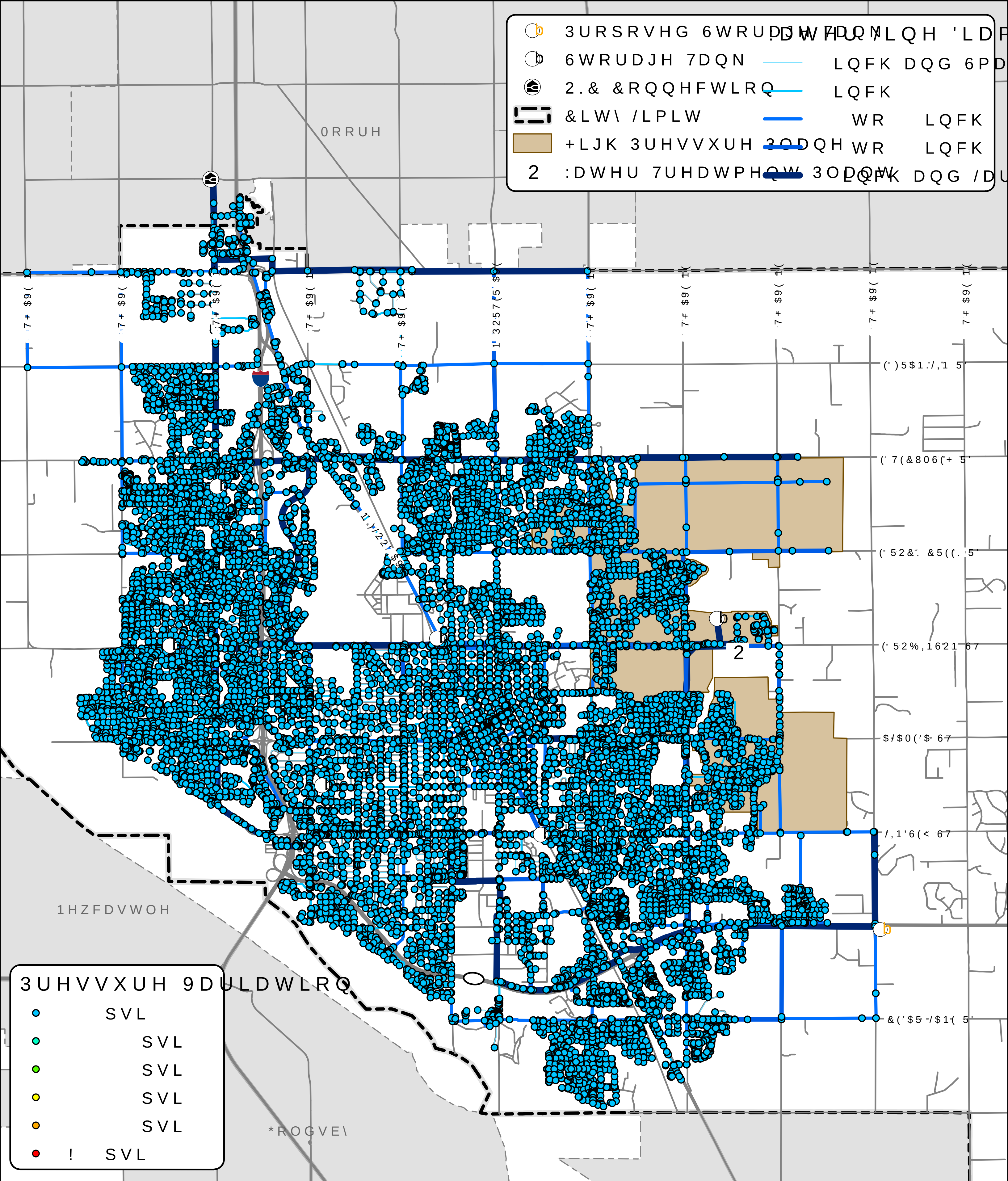

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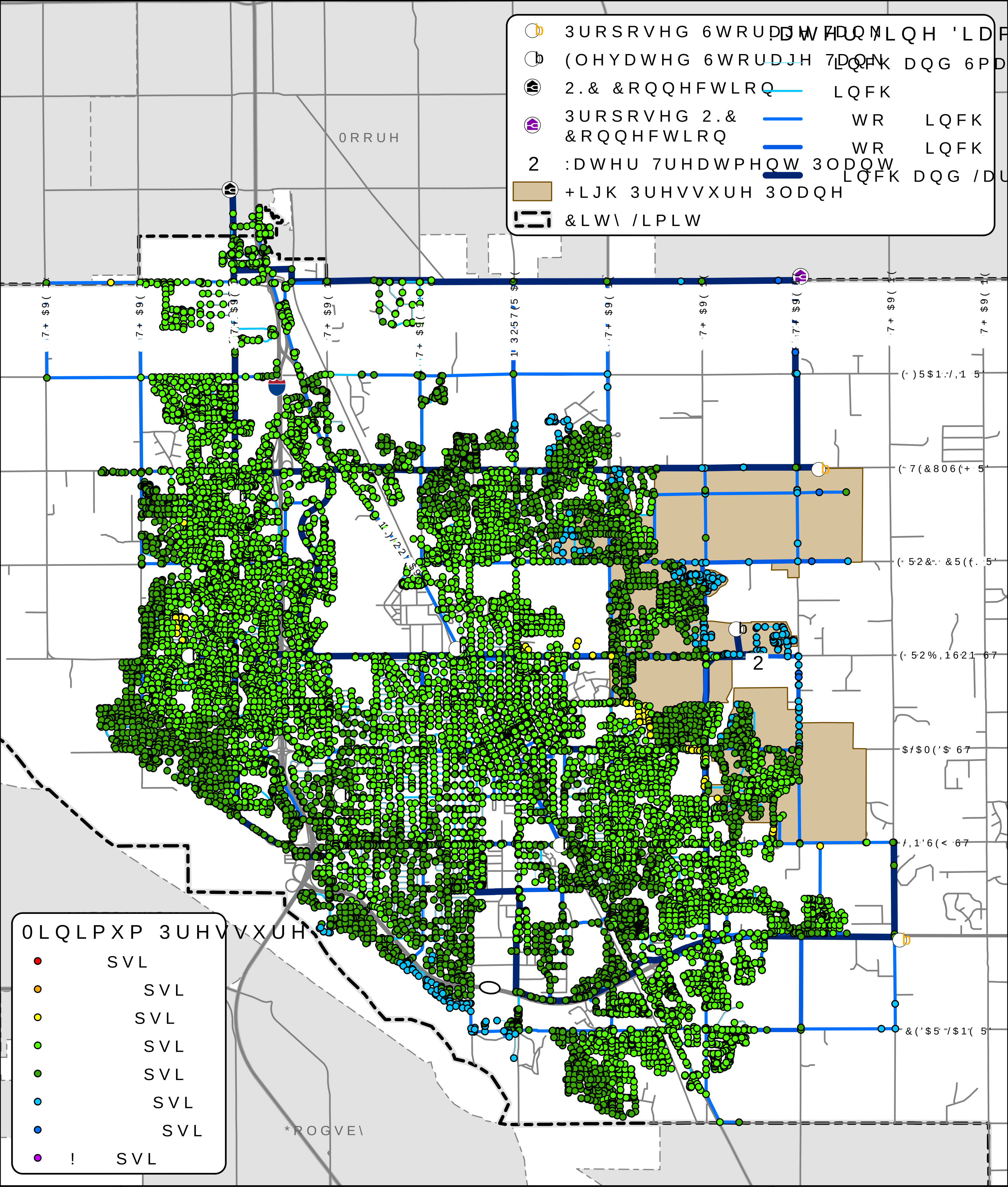

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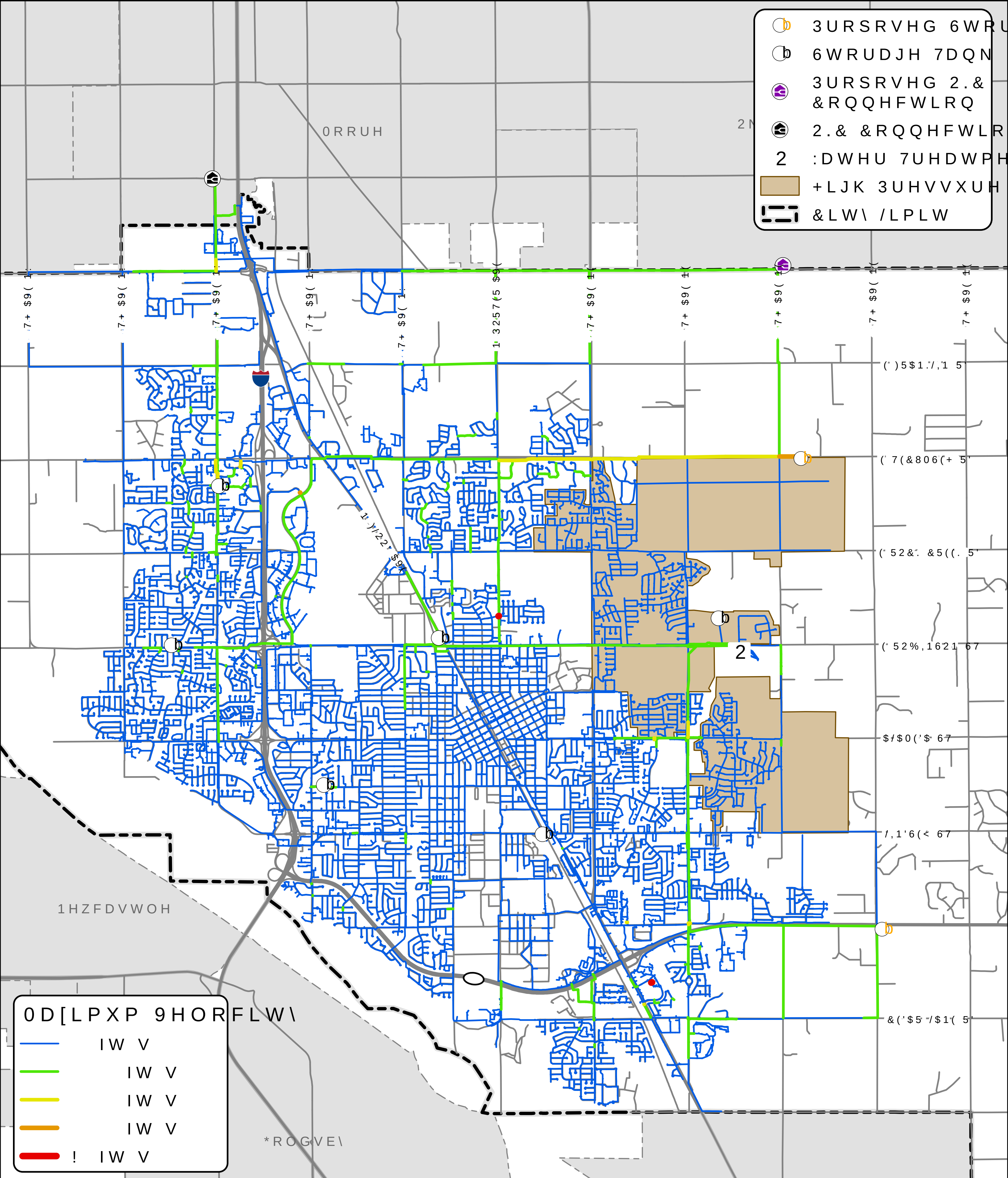

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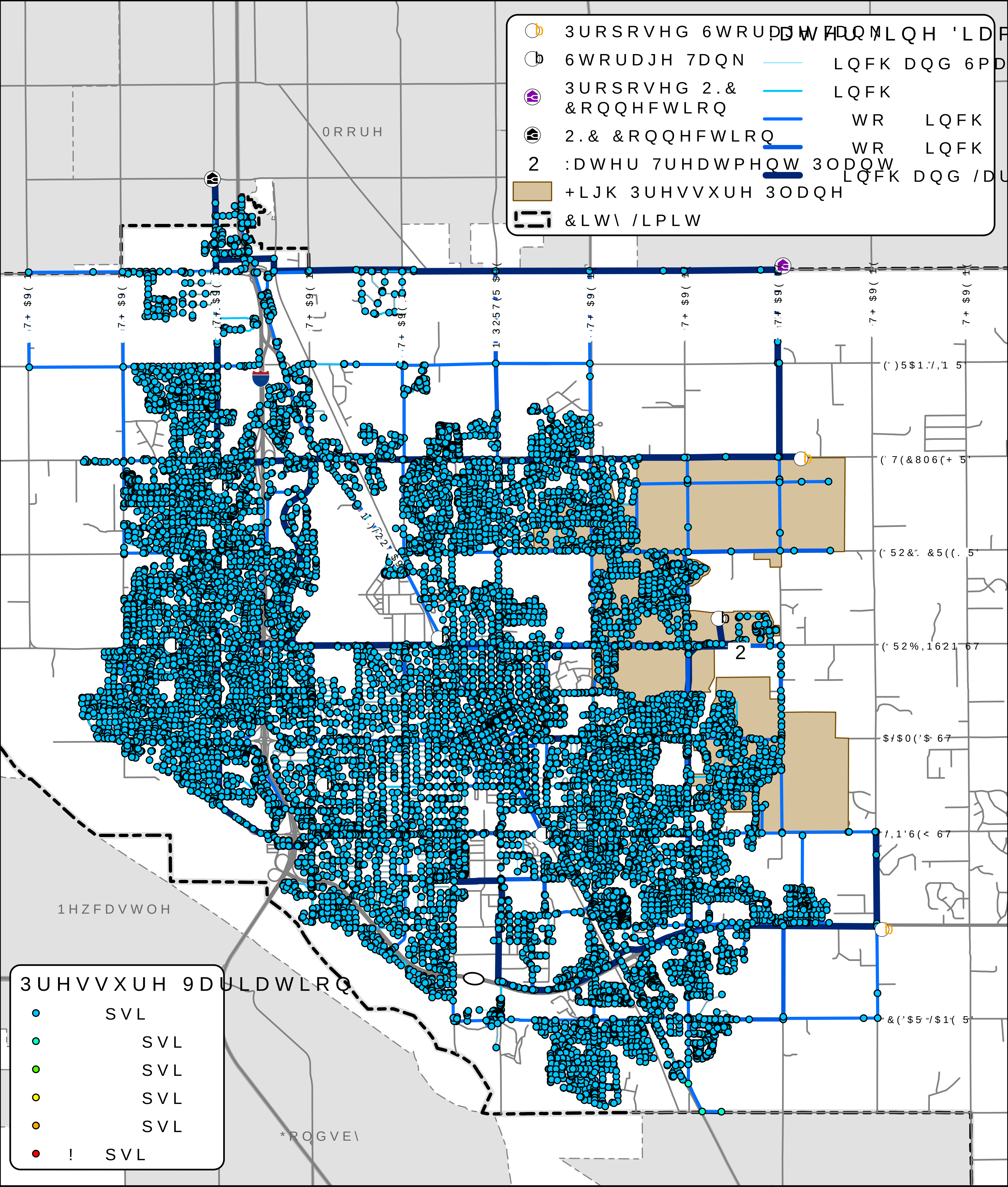

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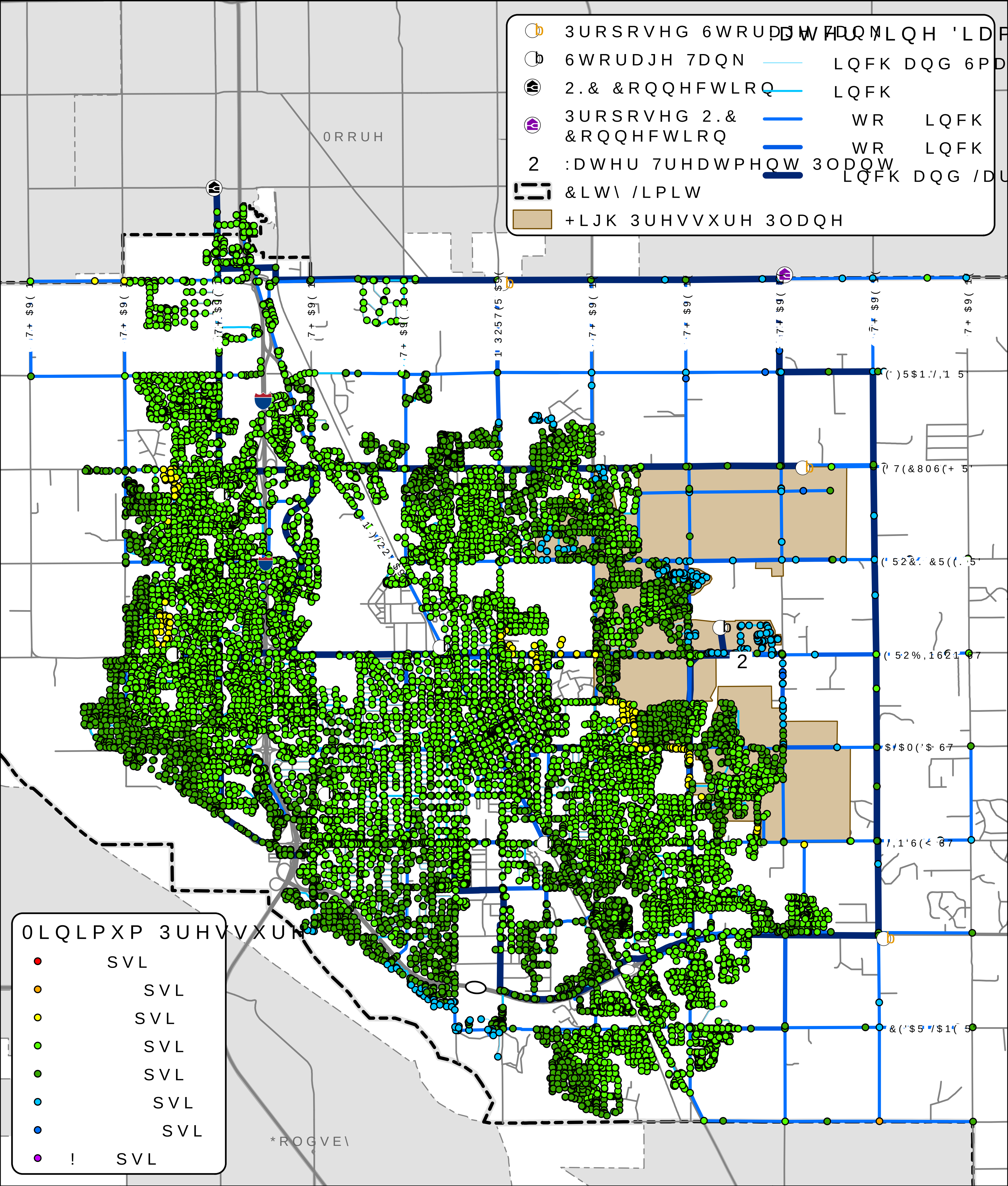

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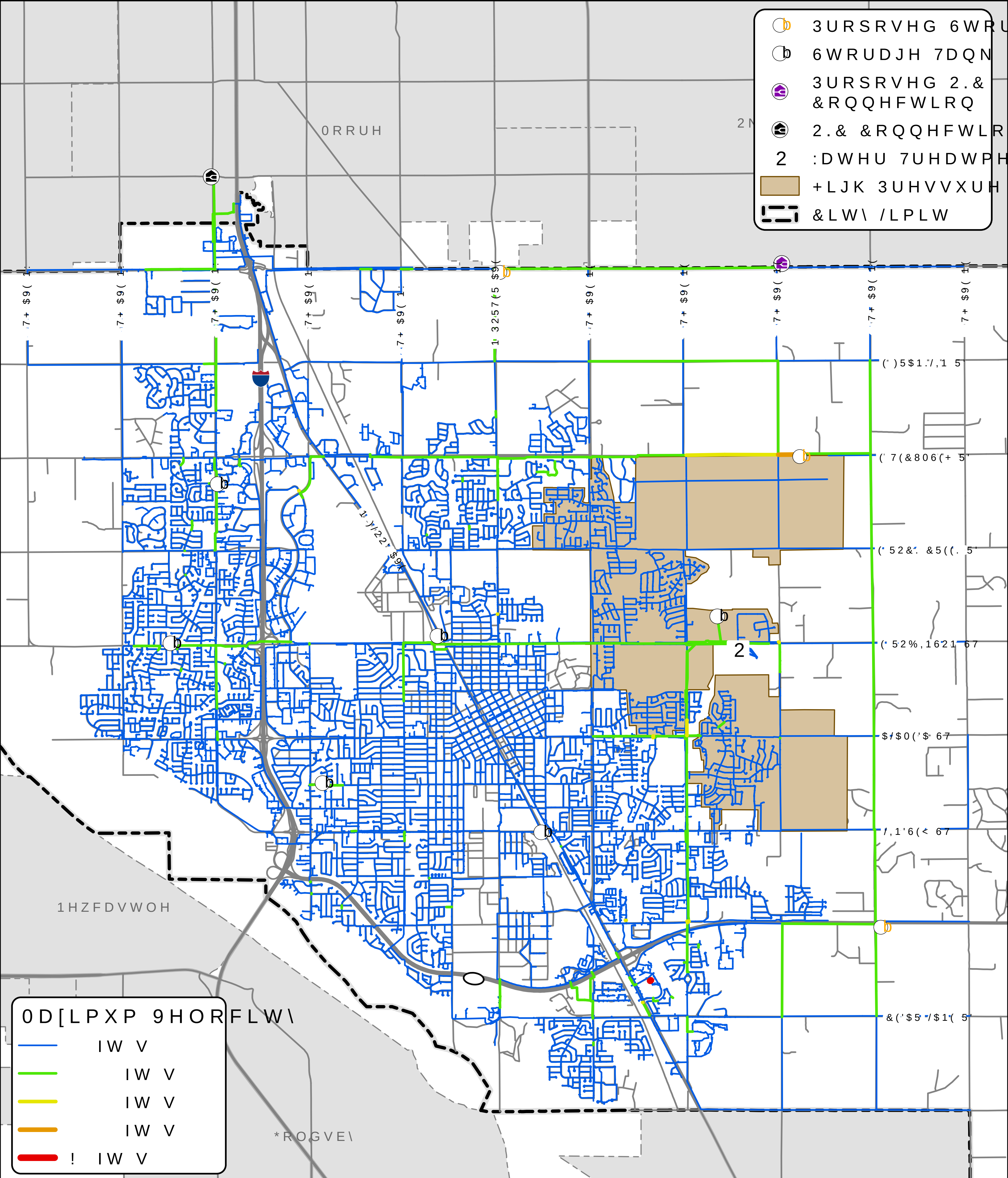

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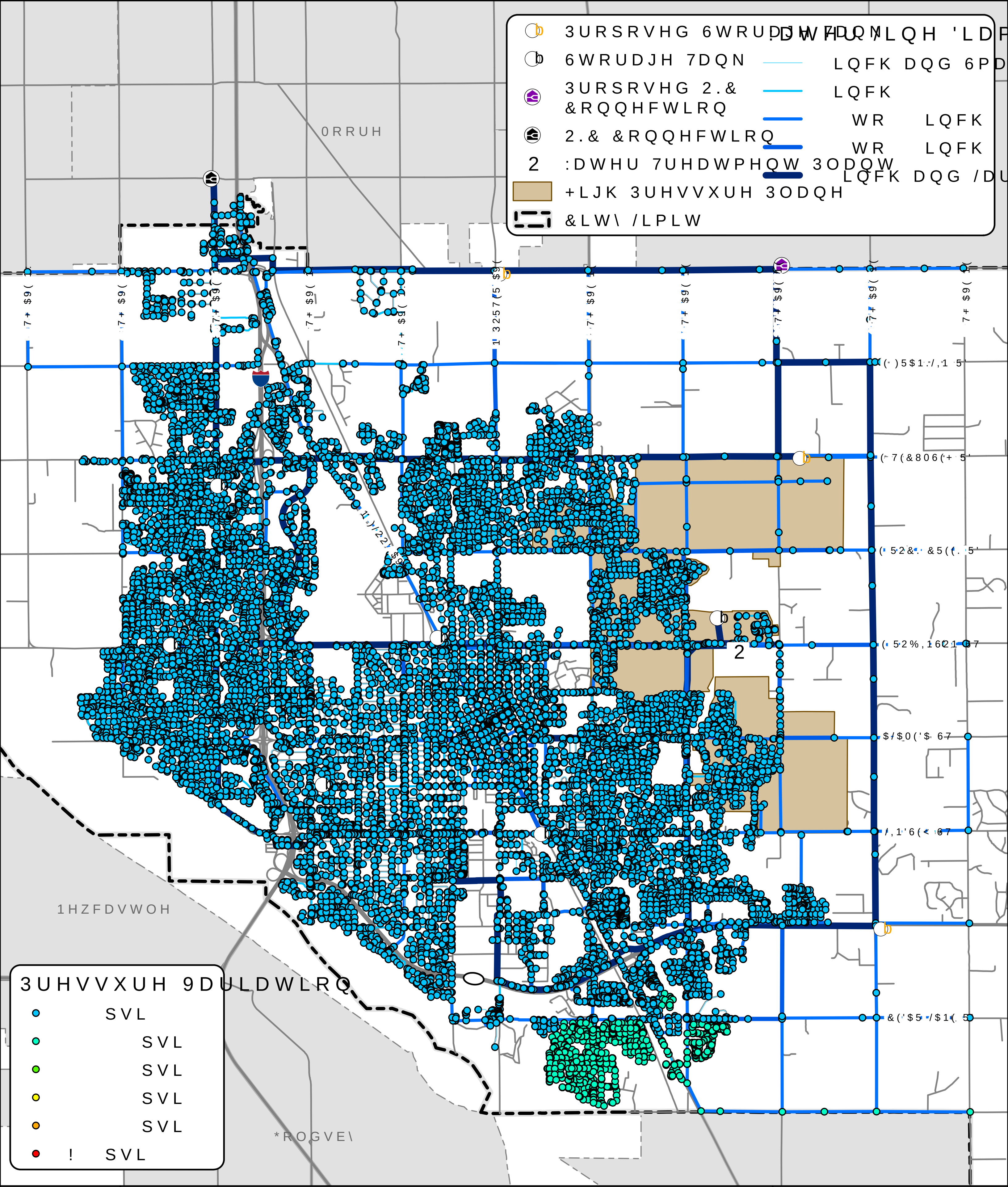

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APPENDIX H

CIP COST ESTIMATES

Project 1: Chautauqua Loop				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
12	Pipe Installation	$ 300	1,265	$ 380,000
			Construction Subtotal	$ 380,000
			30% Contingency (Construction Subtotal)	$ 114,000
			20% Professional Services Contingency - Design, Bidding, and Construction Se	$ 99,000
			10% Easement Acquisition Contingency	$ 50,000
			Total Project Cost with Cost Contingencies	$ 643,000

Project 2: Jenkins Loop				
Diameter (in)	**Description**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
24	Pipe Installation	$ 600	3,840	$ 2,304,000
Construction Subtotal				$ 2,304,000
30% Contingency (Construction Subtotal)				$ 692,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 600,000
10% Easement Acquisition Contingency				$ 300,000
Total Project Cost with Cost Contingencies				$ 3,896,000

Project 3: Robinson Transmission Main				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
30	Pipe Installation	$ 750	14,621	$ 10,966,000
30	Railroad Crossing	$ 1,500	165	$ 248,000
Construction Subtotal				$ 11,214,000
30% Contingency (Construction Subtotal)				$ 3,365,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 2,916,000
10% Easement Acquisition Contingency				$ 1,458,000
Total Project Cost with Cost Contingencies				$ 18,953,000

Project 4: Southeast Elevated Storage Tank			
Description	**Unit**	**Quantity**	**Cost**
2-MG EST	LS	1	$ 10,000,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Construction Subtotal			$ 10,250,000
30% Contingency (Construction Subtotal)			$ 3,075,000
10% Professional Services Contingency - Design, Bidding, and Construction Services			$ 1,333,000
10% Easement Acquisition Contingency			$ 1,333,000
Total Project Cost with Cost Contingencies			$ 15,991,000

Project 5a: Eastern Transmission Loop Phase I				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
24	Pipe Installation	$ 600	15,696	$ 9,418,000
24	Highway 9 Crossing	$ 600	207	$ 125,000
Construction Subtotal				$ 9,543,000
30% Contingency (Construction Subtotal)				$ 2,863,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 2,482,000
10% Easement Acquisition Contingency				$ 1,241,000
Total Project Cost with Cost Contingencies				$ 16,129,000

Project 5b: Eastern Transmission Loop Phase II				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
24	Pipe Installation	$ 600	32,893	$ 19,737,000
Construction Subtotal				$ 19,737,000
30% Contingency (Construction Subtotal)				$ 5,922,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 5,132,000
10% Easement Acquisition Contingency				$ 2,566,000
Total Project Cost with Cost Contingencies				$ 33,357,000

Project 6a: Indian Hills Transmission Loop Phase I				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
24	Pipe Installation	$ 600	21,384	$ 12,831,000
24	I-35 Crossing	$ 600	217	$ 131,000
24	Little River Crossing	$ 600	178	$ 107,000
			Construction Subtotal	$ 13,069,000
			30% Contingency (Construction Subtotal)	$ 3,921,000
			20% Professional Services Contingency - Design, Bidding, and Construction Services	$ 3,398,000
			10% Easement Acquisition Contingency	$ 1,699,000
			Total Project Cost with Cost Contingencies	$ 22,087,000

Project 6b: Indian Hills Transmission Loop Phase II				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
24	Pipe Installation	$ 600	21,578	$ 12,947,000
24	North Fork Creek Crossing	$ 1,200	145	$ 174,000
			Construction Subtotal	$ 13,121,000
			30% Contingency (Construction Subtotal)	$ 3,937,000
			20% Professional Services Contingency - Design, Bidding, and Construction Services	$ 3,412,000
			10% Easement Acquisition Contingency	$ 1,706,000
			Total Project Cost with Cost Contingencies	$ 22,176,000

Project 7: Groundwater Treatment Ground Storage Tank & Pump Station			
Description	**Unit**	**Quantity**	**Cost**
2-MG GST and Pump Station	LS	1	$ 10,000,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Construction Subtotal			$ 10,250,000
30% Contingency (Construction Subtotal)			$ 3,075,000
10% Professional Services Contingency - Design, Bidding, and Construction Services			$ 1,333,000
10% Easement Acquisition Contingency			$ 1,333,000
Total Project Cost with Cost Contingencies			$ 15,991,000

Project 8: Groundwater Treatment Facility Piping to System				
Diameter (in)	Description	Unit Cost ($/LF)	Length (LF)	Cost
24	Pipe Installation	$ 600	9,107	$ 5,465,000
Construction Subtotal				$ 5,465,000
30% Contingency (Construction Subtotal)				$ 1,640,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 1,421,000
10% Easement Acquisition Contingency				$ 711,000
Total Project Cost with Cost Contingencies				$ 9,237,000

Project 9: North Elevated Storage Tank			
Description	**Unit**	**Quantity**	**Cost**
2-MG EST	LS	1	$ 10,000,000
Electrical	LS	1	$ 50,000
Site Improvements	LS	1	$ 200,000
Construction Subtotal			$ 10,250,000
30% Contingency (Construction Subtotal)			$ 3,075,000
10% Professional Services Contingency - Design, Bidding, and Construction Services			$ 1,333,000
10% Easement Acquisition Contingency			$ 1,333,000
Total Project Cost with Cost Contingencies			$ 15,991,000

Project 10a: New Garber-Wellington Wells Phase I				
Description		Unit Cost	Quantity	Cost
Groundwater Wells		$ 1,000,000	10	$ 10,000,000
Description	Diameter (in)	Unit Cost ($/LF)	Length (LF)	Cost
Raw Water Line	20	$ 500	7,920	$ 3,960,000
Raw Water Line	16	$ 400	10,560	$ 4,224,000
Raw Water Line	12	$ 300	7,920	$ 2,376,000
Construction Subtotal				$ 20,560,000
30% Contingency (Construction Subtotal)				$ 6,168,000
25% Professional Services Contingency - Design, Bidding, and Construction Services				$ 6,682,000
10% Easement Acquisition Contingency				$ 2,673,000
Total Project Cost with Cost Contingencies				$ 36,083,000

Project 10b: New Garber-Wellington Wells Phase II				
Description		Unit Cost	Quantity	Cost
Groundwater Wells		$ 1,000,000	10	$ 10,000,000
Description	Diameter (in)	Unit Cost ($/LF)	Length (LF)	Cost
Raw Water Line	20	$ 500	7,920	$ 3,960,000
Raw Water Line	16	$ 400	10,560	$ 4,224,000
Raw Water Line	12	$ 300	7,920	$ 2,376,000
Construction Subtotal				$ 20,560,000
30% Contingency (Construction Subtotal)				$ 6,168,000
25% Professional Services Contingency - Design, Bidding, and Construction Services				$ 6,682,000
10% Easement Acquisition Contingency				$ 2,673,000
Total Project Cost with Cost Contingencies				$ 36,083,000

Project 11: Second OKC Connection				
Description		**Unit**	**Quantity**	**Cost**
Connection Control Meter Vault		LS	1	$ 1,120,000
Description	**Diameter (in)**	**Unit Cost ($/LF)**	**Length (LF)**	**Cost**
Pipe Installation	24	$ 600	21,120	$ 12,672,000
Construction Subtotal				$ 13,792,000
30% Contingency (Construction Subtotal)				$ 4,138,000
20% Professional Services Contingency - Design, Bidding, and Construction Services				$ 3,586,000
10% Easement Acquisition Contingency				$ 1,793,000
Total Project Cost with Cost Contingencies				$ 23,309,000

Project 12: Reuse Water Supply System			
Description	**Unit**	**Quantity**	**Cost***
10 MGD WRF IPR Upgrade	LS	1	$ 86,625,000
IPR Effluent Conveyance	LS	1	$ 23,637,138
Raw Water Conveyance Improvements	LS	1	$ 13,296,542
WTP Capacity Improvements	LS	1	$ 75,937,500
Construction Subtotal			$ 199,497,000
30% Contingency (Construction Subtotal)			$ 59,850,000
25% Professional Services Contingency - Design, Bidding, and Construction Services			$ 64,837,000
10% Easement Acquisition Contingency			$ 25,935,000
Total Project Cost with Cost Contingencies			$ 350,119,000

*Full cost break downs for each line item can be found in the Reuse Evaluation Technical Memorandum (Appendix B)