RECLAMATION

Managing Water in the West

TECHNICAL MEMORANDUM

Submitted to the Chickasaw Nation and City of Sulphur, Oklahoma
Prepared by the Bureau of Reclamation, Oklahoma-Texas Area Office, Native American Technical Assistance Program

A Preliminary Assessment of Non-Potable Reuse Alternatives for the City of Sulphur

U.S. Department of the Interior
Bureau of Reclamation

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

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

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ACRONYMS

BOD	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand
CIEUW	Commercial and Institutional End Uses of Water
DEQ	Department of Environmental Quality
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
EQ	equalization
FAC	Project Planning and Facility Operations, Maintenance, and Rehabilitation
ft	feet
gal/ft	gallons per foot
GPCD	Gallons per Capita Day
GPM	Gallons per Minute
gpd	gallons per day
MOR	Monthly Operations Reports
mgd	million gallons per day
MGY	million gallons per year
CNRA	Chickasaw National Recreation Area
O&M	Operations and Maintenance
OCWP	Oklahoma Comprehensive Water Plan
OWRB	Oklahoma Water Resources Board
%	percent
POE	Point-of-Entry
RWD	Rural Water District
SBR	sequencing batch reactor
TM	Technical Memorandum
TSS	total suspended solids
USGS	United States Geologic Survey
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The objective of this preliminary assessment, set forth within the context of recommendations included in Reclamation's Appraisal Investigation and Report titled "Sulphur Pipeline Regional Rural Water Supply Project", was to determine whether development of a direct, non-potable reuse water supply alternative for Sulphur could reduce long-term pumping from the Arbuckle-Simpson Aquifer and provide at least 295 acre-feet per year of water by 2060 to meet Sulphur's future projected demands. The preliminary market assessment for this investigation showed that non-potable water reuse use potential currently totals between 38 and 109 acre-feet per year for Category 3 and 2 uses, respectively. For 2060, these uses may increase to between 71 and 160 acre-feet per year.

Although these volumes fall short of the full amount potentially needed to offset Sulphur's projected water supply deficit, benefits of implementing a water reuse project certainly exist, for every acre-foot of water recycled is an acre-foot of potable water offset, which thereby either offsets or postpones an acre-foot of water either pumped out of the Arbuckle-Simpson Aquifer or conveyed from Lake of the Arbuckles (the latter assuming a pipeline is built).

The approach employed in this assessment provides a range of costs associated with implementing a reuse project that services the top water users in Sulphur both with and without WWTP improvements, beginning with the closest customers that provide the largest benefit per unit cost. For example, providing Category 3 recycled water (i.e., for restricted use irrigation) to the nearby Chickasaw Cultural Center yields the greatest unit cost benefit (3.4 million gallons at a cost of about $84,000). These costs are preliminary and based on existing data, and are thus contingent upon numerous factors such final design and actual site conditions. Next steps would include confirmation that the WWTP effluent meets Category 3 regulatory standards associated with turbidity, nutrients and fecal coliform, and chlorine disinfection, as well as direct coordination with potential reuse customers to confirm willingness to participate.

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INTRODUCTION

The Bureau of Reclamation (Reclamation) completed an Appraisal Investigation and Report in December 2013, titled "Sulphur Pipeline Regional Rural Water Supply Project". The investigation was completed by Reclamation at the request of the City of Sulphur using grant funding provided under Reclamation's Rural Water Supply Program. Key findings of this investigation were as follows:

1. The problems and needs in the study area stem from water supply deficits that will occur from groundwater pumping restrictions on the Arbuckle-Simpson Aquifer as ruled by the state of Oklahoma, along with environmental, recreational, and cultural impacts associated with the potential development of new groundwater supplies. If pumping restrictions on the Arbuckle-Simpson Aquifer are in place by 2020[1], a water supply deficit for Sulphur is projected to occur in 2030 and would grow to 295 acre-feet per year by 2060. The needs assessment also included demands for the adjacent Murray County Rural Water District (RWD) No. 1 (and its customers). A supply deficit would occur immediately upon enactment of pumping restrictions and would grow to 1,144 acre-feet per year by 2060. The combined supplies and demands for Sulphur and Murray County RWD No. 1 indicate that a supply deficit could grow to about 1,439 acre-feet per year by 2060.
2. Lake of the Arbuckles was identified as the most suitable surface supply option that could bridge the full water supply deficit, while also allowing Sulphur to develop its full allocation of Lake water rights (1,997 acre-feet per year) held by the Arbuckle Master Conservancy District. Under the proposed alternative, 1,997 acre-feet per year would be released through the existing intake structure at Lake of the Arbuckles and pumped through the existing Wynnewood Aqueduct to the existing regulating reservoir. Water would then be pumped through a new pipeline to a new treatment and storage facility at the southwest corner of Sulphur's municipal water system along Chickasaw Trail and State Highway 7. The total estimated construction cost was estimated to be $18.9 million (2012 dollars). Adding a regional connection to Murray County RWD No. 1 would cost an additional $1.8 million, bringing total construction costs to approximately $20.7 million. The proposed pipeline may yield net regional benefits that outweigh project costs. A more detailed study that includes geotechnical investigations would need to be conducted to more accurately estimate project costs.
3. Further studies should explore the merits of implementing water conservation and reuse, either in addition or in lieu of a new pipeline from Lake of the Arbuckles, as a means of alleviating water supply deficits and potential impacts associated with reduced aquifer and reservoir levels.

The purpose of this Technical Memorandum (TM) is to address the Investigation's recommendation to explore the viability of water reuse as a supply alternative for Sulphur. More specifically, this assessment focuses on "direct, non-potable reuse", as defined below. Three types of water reuse projects exist in water resources management:

1. Direct, non-potable reuse: conveying treated effluent from a wastewater treatment plant directly to customers for non-potable (non-drinking) purposes such as irrigation or air conditioning cooling towers.

[1] A Final Order on the Determination of the Maximum Annual Yield of the Arbuckle Simpson-Aquifer was issued on October 23, 2013; although the order does not establish an implementation timeframe, the year 2020 was assumed for this investigation.

2. Direct, potable reuse: conveying highly advanced-treated effluent from a wastewater treatment plant directly to a raw water treatment plant before being distributed as drinking water.
3. Indirect, potable reuse: conveying treated effluent from a wastewater treatment plant through an environmental buffer (such as a lake or a constructed wetland) before being treated at a raw water treatment where it is distributed as drinking water.

The latter two water reuse categories are not the subject of this assessment due to limited time and availability of funding.

Authority

This TM was conducted under Reclamation's Native American Affairs Technical Assistance Program (http://www.usbr.gov/native/programs/techasst_activities_tap.html). This program supports a broad range of activities, including, but not limited to: water needs assessments; evaluations of municipal, industrial, and rural water systems; recommendations on improved water management strategies; or other planning and engineering studies. Work is typically performed by Reclamation staff through cooperative working relationships with the tribes to provide the tribes with opportunities to benefit from Reclamation's technical expertise and resources. Funding is awarded on a competitive basis through solicitations that are advertised each year, contingent upon appropriations.

The Chickasaw Nation partnered with the City of Sulphur and applied for and was awarded $49,000 in program funding for Fiscal Year 2014 to evaluate the viability of implementing a direct, non-potable water reuse project within Sulphur. The Nation selected Reclamation to perform the work, which is the subject of this report.

Problems and Needs

The problems and needs in the study area stem from water supply deficits that will occur from groundwater pumping restrictions on the Arbuckle-Simpson Aquifer as ruled by the state of Oklahoma, as well as the long-term environmental, recreational, and cultural impacts associated with the potential development of new groundwater supplies. If pumping restrictions on the Arbuckle-Simpson Aquifer are in place by 2020[2], a water supply deficit for Sulphur is projected to occur in 2030. For other entities in the area, this deficit would occur immediately. Several entities in the region, including Sulphur, RWDs, and Ada, currently utilize groundwater supply from the Arbuckle-Simpson Aquifer for their drinking water. In recognition of the aquifer's historical, environmental, cultural, and recreational significance, and in response to proposals to transfer groundwater out of the basin, state legislation (Senate Bill 288) was enacted that mandated an evaluation of the impacts of groundwater pumping on the aquifer and its associated springs, streams, and lakes. The Oklahoma Water Resources Board (OWRB), in collaboration with Reclamation, U.S. Geological Survey (USGS), National Park Service, and several local entities, completed a seven-year study in 2010 on the hydrology of the Arbuckle-Simpson Aquifer (OWRB and USGS, 2011). Following the study, the OWRB issued a Final Determination of Maximum Annual Yield ordering a 0.2 acre-foot per acre per year equal proportionate part of the yield to be allocated to each surface acre overlying the aquifer (OWRB

[2] A Final Order on the Determination of the Maximum Annual Yield of the Arbuckle Simpson-Aquifer was issued on October 23, 2013; although the order does not establish an implementation timeframe, the year 2020 was assumed for this investigation.

2013). This represents a *90 percent* reduction from the current temporary pumping rates of 2.0 acre-feet per acre.

Therefore, many entities, including Sulphur, that currently depend on the aquifer are seeking alternative surface water supply options. These alternative supplies will not only help meet future water needs, they will potentially help mitigate long-term impacts on the numerous resources associated with the Arbuckle-Simpson Aquifer.

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EXISTING AND PROJECTED SUPPLIES AND DEMANDS

Sulphur's Supplies and Demands

Sulphur receives its water from seven groundwater wells in the Arbuckle-Simpson Aquifer. The City provides this water through two types of existing groundwater right permits: (1) a 1,120 acre-feet per year "prior right" permit; and (2) a 257 acre-feet per year "temporary right" permit, the sum of which totals 1,377 acre-feet per year. Sulphur also has an allocation of 1,997 acre-feet per year of surface water rights from Lake of the Arbuckles, which are held by the Arbuckle Master Conservancy District. However, the infrastructure to convey this water was never built, so Sulphur is currently limited to its existing 1,377 acre-feet per year groundwater right.

It is important to note that, although Sulphur's prior right permit would not be subject to pumping restrictions, its temporary permit will be subject to restrictions. A prior right is a right to use groundwater established under state laws as they existed prior to July 1, 1973, with such rights being recognized in final orders of the OWRB determining prior rights to use groundwater. A temporary right, as defined by 82 O.S. Section 102.11B, is an authorization to put groundwater to beneficial use prior to completion of a hydrologic survey and determination of the maximum annual yield of an aquifer. With the recent completion of a Final Determination on the maximum annual yield of the Arbuckle-Simpson Aquifer, the OWRB has set forth a proposed process by which Sulphur's temporary permits would be converted to "regular" permits that impose the reduced equal proportionate share of the maximum annual yield to be allocated to each acre overlying the aquifer. Under the Determination, pumping rates will be reduced from 2.0 acre-feet per acre to 0.2 acre-feet per acre, thereby decreasing Sulphur's temporary groundwater right by 90 percent, from 257 acre-feet per year[3] to 25.7 acre-feet per year. Sulphur's total existing water supply would be reduced to 1,146 acre-feet per year. For the purposes of this analysis, reductions are assumed to be in place by 2020.

Based on the recently published 2012 Oklahoma Comprehensive Water Plan (OWCP), Sulphur's 2010 water demand was 961 acre-feet per year. Using population data and a 165 gallons per capita per day usage (GPCD) from prior years, the Oklahoma Comprehensive Water Plan (OCWP) projected Sulphur's water demand to be 1,441 acre-feet per year by 2060. These supply and demand data show that a water supply deficit would exist around 2030 and would grow to 295 acre-feet per year by 2060 (Table 1 and Figure 1). Alternatively more recent population projections were developed by the Oklahoma Department of Commerce for Murray County in 2012. These projections forecast the population of the county growing at a lesser rate than the OWCP. County wide variations were not speculated in the report, but if the marginal growth is assumed at the same rate for Sulphur as for the entire county, Sulphur's water demand is projected to be 1,115 acre-feet per year by 2060.

Regional Supplies and Demands

Murray County RWD No. 1 operates three groundwater wells in the Arbuckle-Simpson Aquifer through an existing temporary groundwater right permit for 764 acre-feet per year[4]. It does not

[3] The land dedicated to this temporary water rights permit totals 128 acres.

[4] The land dedicated to this temporary permit totals 382 acres.

have a prior right groundwater permit. Murray County RWD No. 1 currently sells water to the town of Dougherty[5] and to Buckhorn RWD, the latter of which does not have any other water supply source. Assuming pumping rates are reduced from 2.0 acre-feet per acre to 0.2 acre-feet per acre; Murray County RWD No. 1's temporary groundwater right would be projected to decrease by 90 percent, from 764 acre-feet per year to 76 acre-feet per year. As previously stated, for the purposes of this analysis, these reductions will be in place by 2020. Details are provided in Table 1 below.

Based on the 2012 OWCP, Murray County RWD No. 1's 2010 demands were 813 acre-feet per year. Using population data and average per capita day use, the OCWP projected Murray County RWD No. 1's water demands to be 1,220 acre-feet per year. These supply and demand data show that a water supply deficit currently exists and would grow to 1,144 acre-feet per year by 2060. Table 1 provides detailed numbers and Figure 2 below illustrates the supplies and demands of both RWDs combined.

Table 1 and Figure 3 also show the combined demands and projected supply deficits of both Sulphur and the Murray County RWD No. 1.

Water Conservation

The future demands projected by the OCWP could be reduced through implementation of water conservation measures. These include, but are not limited to, (1) volumetric pricing (i.e., conservation-based rate structure) where water rates are allocated based on volume used[6]; (2) developing a drought contingency plan that includes restrictions on outdoor water use during drought conditions; (3) installing/updating water meters to better account for water use and improve leak detection; (4) maintaining conveyance infrastructure to improve water delivery efficiency; (5) mandating or providing incentives for installation of high water efficiency fixtures in residential/commercial developments; (6) increasing public awareness through education.

For the purposes of this investigation, a 2060 water consumption target of 114 GPCD was estimated as an amount that could potentially be realized through implementation of long-term water conservation measures[7]. This would require about a 10 GPCD reduction each decade from 2020 to 2060. Based on this usage, Sulphur's projected 2060 water demands could be reduced from 1,441 acre-feet per year to 984 acre-feet per year, thereby eliminating a potential water supply deficit by 2060 (Figure 1). It is important to note that recent investments into Sulphur's economic development may promote population growth (and water demands) beyond that which was assumed to occur under these current estimates. Similar to Sulphur, regional demands could be reduced through implementation of water conservation measures. Using a 2060 usage target of 114 GPCD, 2060 demands of Murray County RWD No. 1 could be reduced from 1,220 acre-feet per year to 1,088 acre-feet per year, thereby slightly reducing their 2060 water deficit from

[5] Dougherty also has a contract with Arbuckle Master Conservancy District for 112 acre-feet per year of water.

[6] Generally, the first rate block should include the average usage per residential meter per month, with 25 – 50 percent rate increases for each subsequent block, with no more than three blocks.

[7] This usage value was determined to be an aggressive, yet achievable target based on usage rates of other communities with water conservation programs.

1,144 acre-feet per year to 1,009 acre-feet per year[8]. Table 1 and Figure 2 below illustrates Murray County RWD No. 1's supplies and demands, both with and without water conservation.

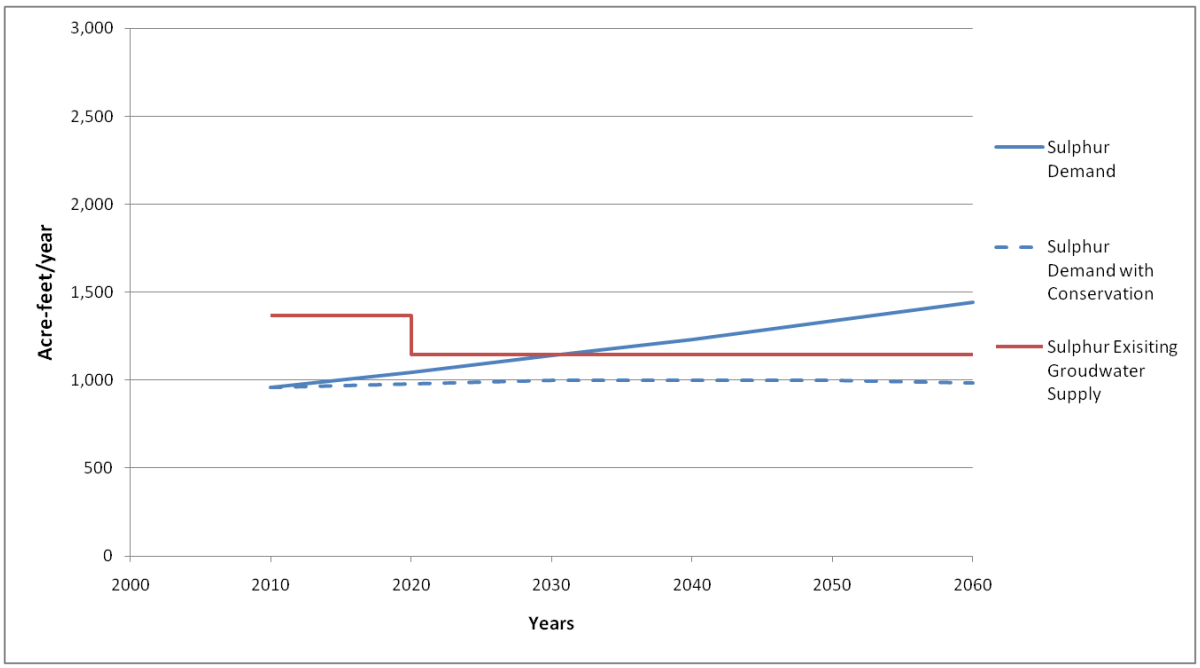

Figure 1. Existing and projected supplies and demands for Sulphur, both with and without conservation. Projections assume a 90 percent reduction in temporary groundwater rights. Note – pumping restrictions are assumed to be in place by 2020.

[8] The benefits of water conservation would be realized through measures undertaken by Buckhorn RWD and Dougherty, which currently have a GPCD usage of 185 and 174, respectively. The GPCD usage of Murray County RWD No. 1 is already at 114.

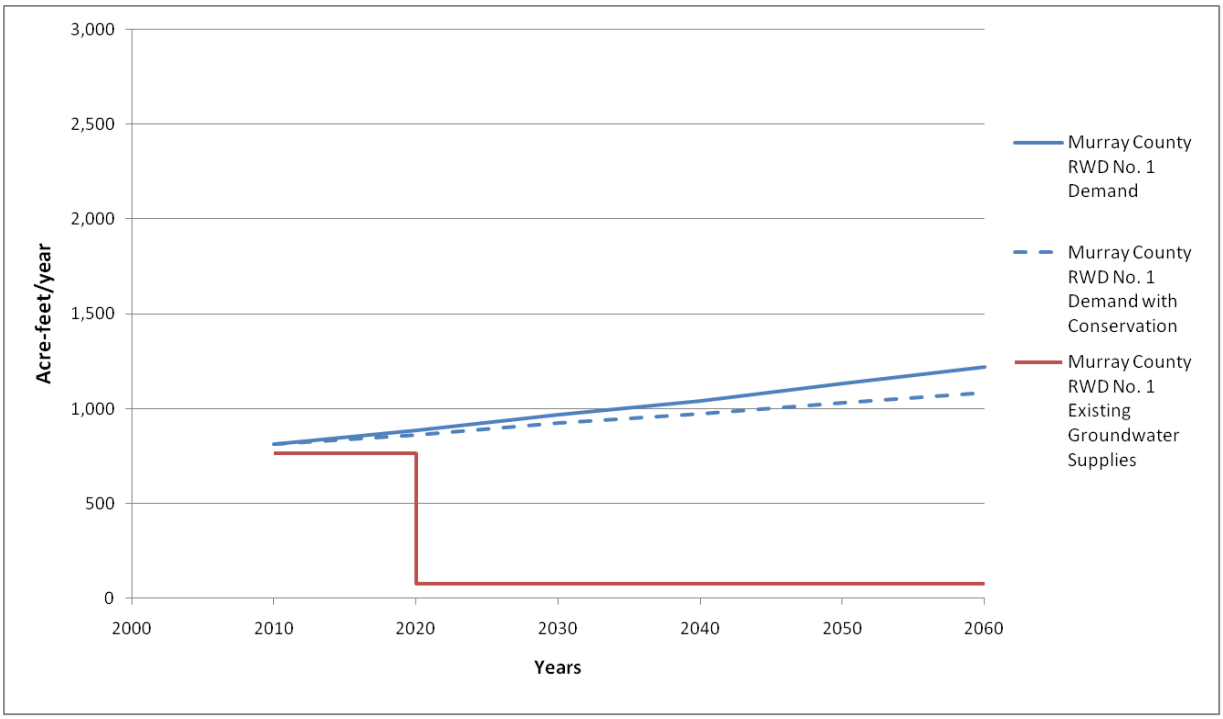

Figure 2. Existing and projected supplies and demands for Murray County RWD No. 1, both with and without conservation. Projections assume a 90 percent reduction in temporary groundwater rights. Note – pumping restrictions are assumed to be in place by 2020. Buckhorn RWD and Dougherty demands are included.

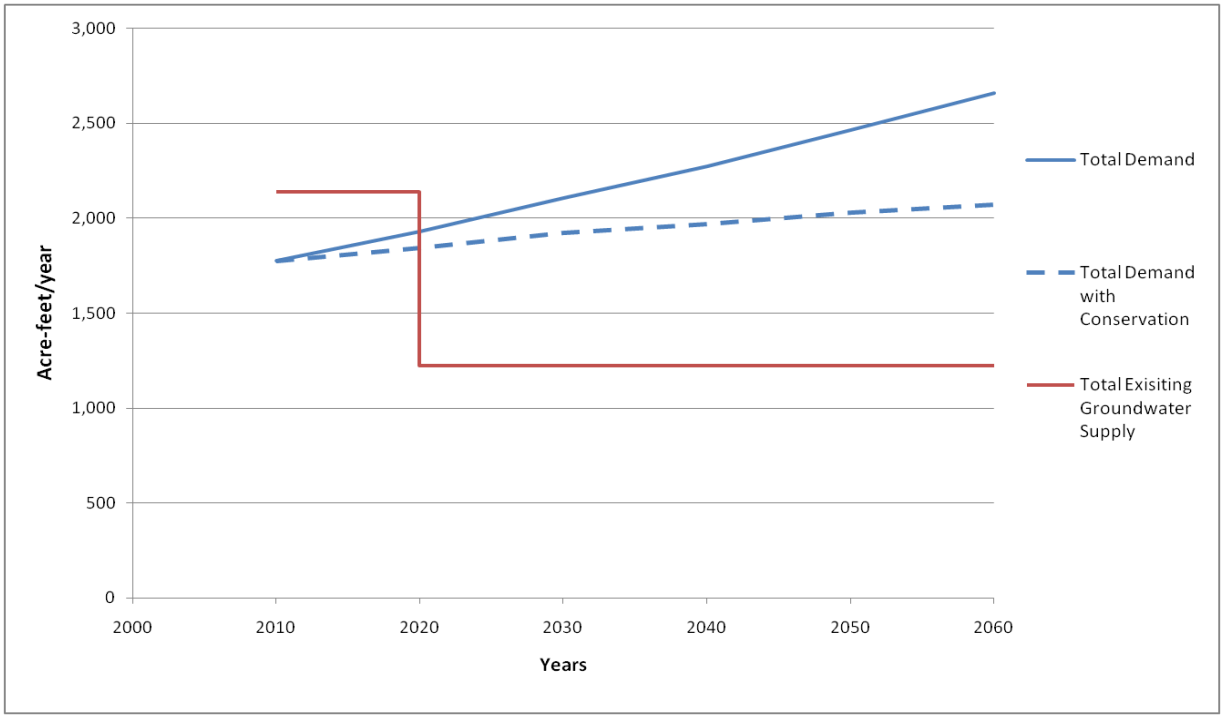

Figure 3. Existing and projected supplies and combined demands for Sulphur and Murray County RWD No. 1, both with and without water conservation. Projections assume a 90 percent reduction in temporary groundwater rights. Note – pumping restrictions are assumed to be in place by 2020. Buckhorn RWD and Dougherty demands are included.

Table 1. Summary of supplies and demands of Sulphur, Murray County RWD No. 1, Buckhorn RWD, and Dougherty.

DEMANDS (acre-feet per year)							
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Sulphur		961	1,045	1,142	1,232	1,336	1,441
Murray Co. RWD No. 1		576	625	684	738	801	863
Buckhorn RWD		192	209	228	246	267	288
Dougherty		45	50	54	58	63	69
Total		**1,774**	**1,929**	**2,108**	**2,274**	**2,466**	**2,661**
DEMANDS with Conservation (acre-feet per year)							
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Sulphur		961	979	997	998	997	984
Murray Co. RWD No. 1		576	625	684	738	801	863
Buckhorn RWD		192	192	193	189	185	177
Dougherty		45	47	47	46	46	45
Total		**1,774**	**1,843**	**1,921**	**1,971**	**2,029**	**2,069**
EXISTING SUPPLIES - Groundwater							
		2010	**2020**	**2030**	**2040**	**2050**	**2060**
Sulphur	Prior Rights Permit	1,120	1,120	1,120	1,120	1,120	1,120
	Temporary Rights Permit[2]	257	26	26	26	26	26
	Total	*1,377*	*1,146*	*1,146*	*1,146*	*1,146*	*1,146*
	Surplus/Deficit	***416***	***101***	***4***	***(86)***	***(190)***	***(295)***
	***Surplus/Deficit** with Conservation*	**416**	**167**	**148**	**148**	**148**	**162**
Murray Co. RWD No. 1[3]	Prior Rights Permit	0	0	0	0	0	0
	Temporary Rights Permit[2]	764	76	76	76	76	76
	Total	*764*	*76*	*76*	*76*	*76*	*76*
	Surplus/Deficit	***188***	***(549)***	***(608)***	***(662)***	***(725)***	***(787)***
	***Surplus/Deficit** with Conservation*	***188***	***(549)***	***(608)***	***(662)***	***(725)***	***(787)***
Buckhorn RWD	Prior Rights Permit	0	0	0	0	0	0
	Temporary Rights Permit	0	0	0	0	0	0
	Total	*0*	*0*	*0*	*0*	*0*	*0*
	Surplus/Deficit	***(192)***	***(209)***	***(228)***	***(246)***	***(267)***	***(288)***
	***Surplus/Deficit** with Conservation*	***(192)***	***(192)***	***(193)***	***(189)***	***(185)***	***(177)***
Dougherty	Prior Rights Permit	0	0	0	0	0	0
	Temporary Rights Permit	0	0	0	0	0	0
	Total	*0*	*0*	*0*	*0*	*0*	*0*
	Surplus/Deficit	***(45)***	***(50)***	***(54)***	***(58)***	***(63)***	***(69)***
	***Surplus/Deficit** with Conservation*	***(45)***	***(47)***	***(47)***	***(46)***	***(46)***	***(45)***
Total Surplus/Deficit		**367**	**(707)**	**(886)**	**(1,052)**	**(1,245)**	**(1,439)**
Total Surplus/Deficit with Conservation		**367**	**(621)**	**(699)**	**(749)**	**(807)**	**(847)**

Blue font indicates a surplus & red font and parenthesis indicates a deficit

[2] Assumes pumping restrictions are in place by 2020

[3] Buckhorn RWD and Dougherty purchases water from Murray Co. RWD No. 1

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PLANNING OBJECTIVE

The reuse of highly treated wastewater effluent for non-potable purposes such as irrigation is a commonly employed method of reducing potable water needs. Sulphur completed the construction of a new sequencing batch reactor (SBR) wastewater treatment plant (WWTP) in 2010. The plant is located southwest of Sulphur and has a permitted design capacity of 1.5 million gallons per day (mgd). The purpose of this preliminary assessment is to evaluate the viability of using the treated WWTP effluent for direct non-potable water reuse for Sulphur. This report focuses on four key areas:

- Identification of the State of Oklahoma regulatory requirements for wastewater reuse, including specific requirements for each "use" category.
- Evaluation of the Sulphur WWTP effluent flows and water quality for potential direct non-potable wastewater reuse.
- Assessment of current and future recycled water market potential.
- Formulation of conveyance and treatment alternatives, including preliminary costs.

The planning objective of this preliminary investigation is to determine whether development of a direct non-potable reuse water supply alternative for Sulphur could reduce long-term pumping from the Arbuckle-Simpson Aquifer and provide at least 295 acre-feet per year of water by 2060 to meet Sulphur's future potential water supply deficit.

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OKLAHOMA WASTEWATER REUSE REGULATIONS

Reuse of wastewater treatment plant effluent in the State of Oklahoma is regulated under Title 252 of the Department of Environmental Quality (DEQ) Rules and Regulations. The primary requirements are established in Chapter 656 – Water Pollution Control Facility Construction Standards, Subchapter 27 – Wastewater Reuse, with provisions and references to Chapter 627 – Water Reuse for operating, maintenance and monitoring requirements. Subchapters in Chapter 626 – Public Water Supply Construction Standards and Chapter 656 are also referenced for treatment requirements for specific "use" categories. The following provides a summary of the key Oklahoma wastewater reuse regulations.

Chapter 656 – Water Pollution Control Facility Construction Standards, Subchapter 27 – Wastewater Reuse

The primary regulations for wastewater reuse are provided in Chapter 656, Subchapter 27. This subchapter establishes four categories of allowed uses for reclaimed water, which is defined as "wastewater that has gone through various treatment processes to meet specific water quality criteria with the intent of being used in a beneficial manner." This subchapter also establishes the treatment, distribution, and storage requirements for reuse systems. Tables 2 and 3 provide a summary of the allowable uses and treatment requirements for each of the four use categories. Please note that category 1 is reserved for future use.

Table 2. Allowable Uses of Reclaimed Water by Category. [a]

Category	Allowable Uses
2	• Drip irrigation on orchards or vineyards • Spray or drip irrigation on sod farms, public access landscapes and public use areas/sports complexes, including unrestricted access golf courses • Toilet and urinal flushing • Fire protection systems • Commercial closed-loop air conditioning systems • Vehicle and equipment washing (excluding self-service car washes) • Range cattle watering • All category 3, 4 & 5 allowable uses
3	• Subsurface irrigation of orchards and vineyards • Restricted access landscape irrigation • Irrigation of livestock pasture • Concrete mixing • Dust Control • Aggregate washing/sieving • New restricted access golf course irrigation systems • Industrial cooling towers and once-through cooling systems • Restricted access irrigation of sod farms • All category 4 & 5 allowable uses
4	• Soil compaction and similar construction activities • Existing restricted access golf course irrigation systems utilizing water that has received primary treatment in lagoons • All category 5 allowable uses
5	• Restricted access pasture irrigation for range cattle • Restricted access irrigation of fiber, seed, forage and similar crops • Irrigation of silviculture

[a] From Title 252, Chapter 656-27-1.

Table 3. Treatment Requirements for Reclaimed Water by Category. [a]

Category	Treatment Requirements
2	• **Secondary Treatment** - secondary suspended growth mechanical treatment process, or DEQ approved equivalent, capable of meeting effluent limits that are established in Appendix A of Title 252, Chapter 627 • **Nutrient Removal** - biological nutrient removal in accordance with Title 252, Chapter 656-16-3, capable of meeting nutrient removal requirements required based on final use of the reclaimed water; exemptions are available based on agronomic and/or crop uptake rates of the final use • **Coagulation** - coagulation, chemical feed and storage equipment meeting the requirements of Title 252, Chapters 626-9 and 626-11; rapid mixing or inline static mixing also required • **Filtration** - granular media filtration in accordance with Title 252, Chapter 656-23-1 • **Turbidimeters** - continuous on-line turbidimeters following filtration, prior to disinfection • **Disinfection** - chlorination or a combination of UV and chlorination in accordance with Title 252, Chapters 656-21 and 656-3-4(b)(7)(C); disinfection shall achieve 5-log removal or inactivation of Adenovirus type 15 and *Salmonella typhimurium*, and 3-log removal or inactivation of *Giardia lamblia*
3	• **Secondary Treatment** - secondary suspended growth mechanical treatment process, or DEQ approved equivalent, capable of meeting effluent limits that are established in Appendix A of Title 252, Chapter 627 • **Nutrient Removal** - biological nutrient removal in accordance with Title 252, Chapter 656-16-3, capable of meeting nutrient removal requirements required based on final use of the reclaimed water; exemptions are available based on agronomic and/or crop uptake rates of the final use • **Disinfection** - chlorination in accordance with Title 252, Chapter 656-21 at the point of entry into the distribution system
4	• **Primary Treatment** - wastewater lagoon system designed in accordance with Title 252, Chapters 656-11 and 656-25-2(g) & (h) • **Disinfection** - chlorination in accordance with Title 252, Chapter 656-21 at the point of entry into the distribution system • **Storage Detention Time** - following primary treatment, in accordance with Title 252, Chapter 656-25-2(g)
5	• **Primary Treatment** - wastewater lagoon system designed in accordance with Title 252, Chapters 656-11 and 656-25-2(g) & (h)

[a] From Title 252, Chapter 656-27-3.

Subchapter 27 also includes a description of the distribution system and storage requirements for water reuse and include the following:

a. **Piping**. All reclaimed water piping, valves, outlets and appurtenances in distribution systems shall be colored purple (Pantone 522) and shall be embossed or integrally stamped with a warning that includes the following:
   (1) the word "CAUTION;"
   (2) specifies the category number of the reclaimed water; and
   (3) the words "DO NOT DRINK;"
   (e.g.: "CAUTION: CATEGORY #3 RECLAIMED WATER–DO NOT DRINK.") For all pipes, the warning shall be located on opposite sides of all pipes and repeated every three feet (3') or less.

b. **Hose bibs.** Hose bibs shall be located in locked, below-grade vaults. Reclaimed water hose bibs, hydrants and/or similar outlets shall be equipped with warning signs that indicate the water is not safe for drinking.

c. **Gravity pipes.** Reclaimed water gravity pipes shall be designed and constructed to meet the requirements of OAC 252:656-5-2, OAC 252:656-5-3, OAC 252:656-5-4 and OAC 252:656-5-5.

d. **Pumping stations and force mains.** Pumping stations and force mains shall be designed and constructed in accordance with OAC 252:656-7-1 through 4, with the following exceptions:
   (1) Pump openings less than three inches (3") may be allowed when settled or filtered reclaimed water is pumped.
   (2) Water reuse systems with the ability to divert all reclaimed water to the wastewater's permitted discharge point, without operator assistance, may be exempt from the requirement to equip the lift station with emergency wet well storage, backup power supply or duplicate pumps.

e. **Reclaimed water flushing system.** Reclaimed water distribution systems shall be designed with all appurtenances necessary to adequately flush the distribution system to prevent slime growth and the regrowth of pathogens. Flushing plans shall be developed for all reclaimed water distribution systems and submitted for DEQ approval. Flushing plans shall also be included in reclaimed water systems' O&M manuals [see OAC 252: 656-3-10] and in suppliers' DEQ approved inspection programs [see OAC 252:627-1-5(f)]. All flushing systems shall include at a minimum:
   (1) provisions for disposal of flushed water that prevent bypasses and discharges to waters of the state or elsewhere; and
   (2) air gaps designed pursuant to OAC 252:656-9-2 for all discharges to sanitary sewers.

Storage, retreatment, and chlorination requirements are described in subchapter 27-5 and include the following:

a. **Storage.** Reclaimed water may be stored as follows:
   (1) **Storage tanks.** Categories 2-5 reclaimed water may be stored in storage tanks that meet NSF or ASTM standards for public water supply storage tanks.
   (2) **Open storage basins.** Categories 2 and 3 reclaimed water may be stored in open storage basins that are permitted and constructed in compliance with OAC 252:656-11-3 and operated as a lagoon in accordance with OAC 252:619 or OAC 252:621.
   (3) **Lagoons.** Categories 4 and 5 reclaimed water may be stored in lagoons that are permitted and constructed in compliance with OAC 252:656-11-3 and operated in accordance with OAC 252:619 or OAC 252-621.

b. **Retreatment.** Following storage in an open storage basin, Category 2 reclaimed water shall be retreated with filtration and chlorination, at a minimum, to prevent slime growth and regrowth of pathogens to end-of-pipe.

Chapter 656 Subchapter 27 also includes a description of the General Provisions for water reuse. This section requires reclaimed water systems designed to ensure that direct and wind-blown spray from irrigation systems and other sources are confined to the designated irrigation areas.

Table 4 provides a description of the minimum buffer zones and setback distances required for use. Figure 4 provides a map of Sulphur showing the areas of restricted use.

Table 4. Reclaimed water minimum buffer zones and setback distances based on reuse categories.

Features:	Category 2	Category 3, 4, and 5
Wells		
Public Wells	300 ft	300 ft
Private Wells	50 ft	50 ft
Waters of the State		
Streams	25 ft	50 ft
Lakes	25 ft	50 ft
Ponds	25 ft	50 ft
Marshes	25 ft	50 ft
Property Lines	20 ft	100 ft

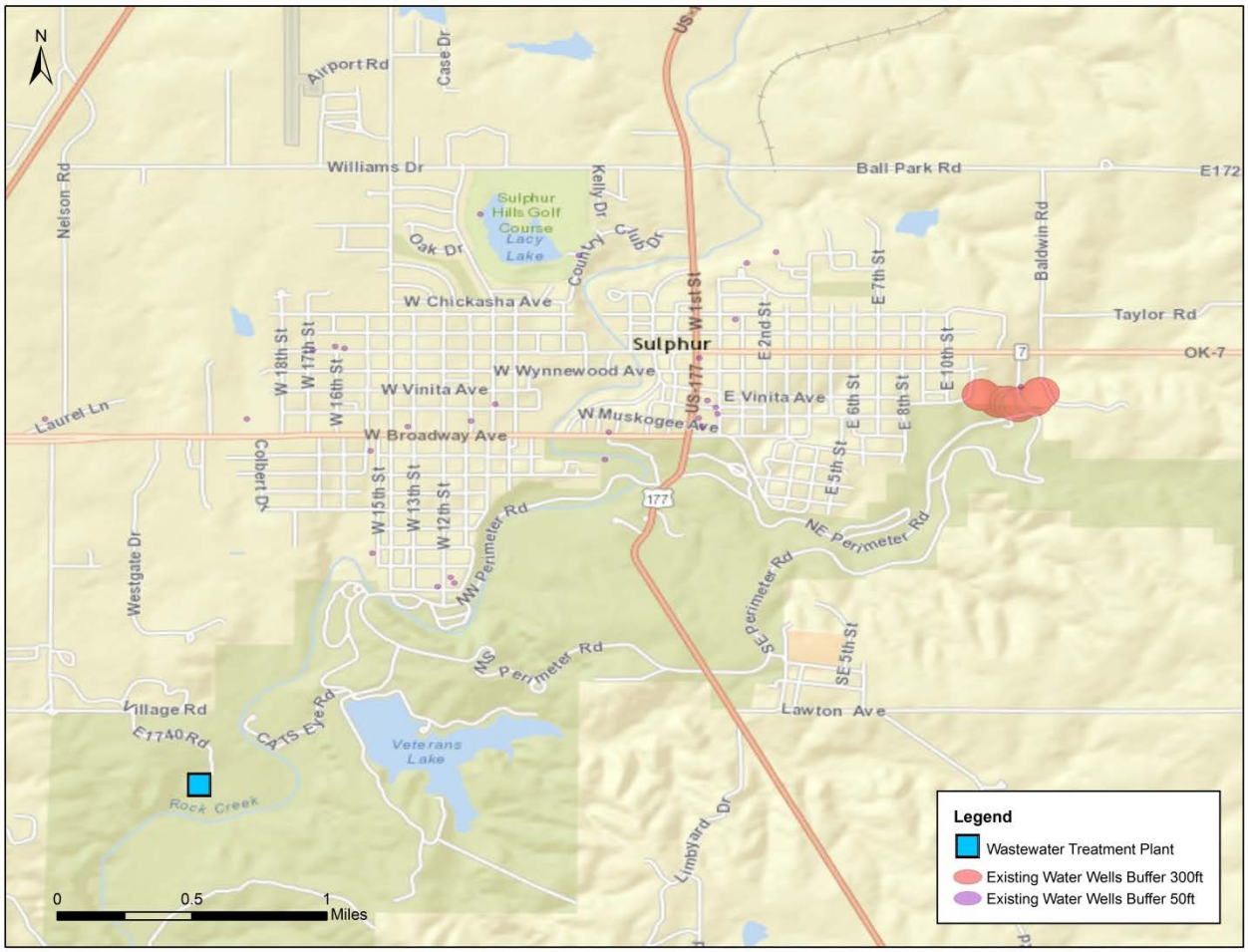

Figure 4. Map of Sulphur showing the areas of restricted use.

Chapter 627 – Water Reuse

Chapter 627 of the Oklahoma DEQ Rules and Regulations establishes the operating requirements for water reuse systems that are permitted or qualify to be permitted under Chapter 656. This chapter includes the permitting requirements and permitted uses. The permitted uses are identical to the allowable uses that are identified in Chapter 656. Chapter 627 also establishes the operation and maintenance (O&M) requirements and restrictions for each use category, and Chapter 627's Appendix A establishes the sampling requirements/limits for each use category. Table 5 provides a summary of Chapter 627's Appendix A's sampling, limits, and reporting requirements.

Table 5. Testing Frequency and Limits for Water Reuse Systems. [a]

Category	Tests (frequency)	Limits	Reporting
2	**Turbidity** (continuous)	Not to exceed the following: • Daily average 2 NTU[b] • 5 NTU >5 percent (%) of the daily max per month[c] • 10 NTU at any time	Submit Monthly Operation Reports (MORs) to DEQ
	Chlorine Disinfection at Point-of-Entry (POE) (continuous)	Free available chlorine residual greater than or equal to 1.0 ppm at POE to distribution system and following any subsequent storage or treatment **OR** Chlorine residual at POE to distribution system and following any subsequent storage or treatment shall be at level to prevent growth of slime and regrowth of pathogens in the distribution and storage systems as determined by an approved chlorine decay rate model pursuant to Title 252, Chapter 656-3-4(b)(7)(C)	
	Chlorine Disinfection at End-of-Pipe (daily)	Free available chlorine residual at the end-of-pipe greater than or equal to 0.20 mg/L **OR** Combined chlorine residual at the end-of-pipe greater than or equal to 0.50 mg/L	
	Fecal Coliform (daily)	No detectable fecal coliform organisms in four of the last seven daily samples, single sample maximum less than or equal to 23 cfu/100 mL	
	Nitrogen/Phosphorus (monthly)	Less than or equal to most stringent agronomic rate	
	Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) (weekly)	Less than 5.0 mg/L	
3	**Chlorine Disinfection** (every 12 hours)	Free available chlorine residual at the POE to the distribution system and following any subsequent storage or treatment shall be greater than or equal to 0.20 ppm **OR** Combined chlorine residual at the POE to the distribution system and following any subsequent storage or treatment shall be greater than or equal to 0.50 mg/L	Maintain MORs On-site

Category	Tests (frequency)	Limits	Reporting
	Fecal Coliform (3 per week)	• Monthly geometric mean of < 200 cfu/100mL • Single sample maximum of < 400 cfu/100mL	
	Nitrogen/Phosphorus (monthly)	Less than or equal to most stringent agronomic rate	
	BOD_5 or $CBOD_5$ (weekly)	Less than 20 mg/L	
4	**Fecal Coliform** (weekly)	• Monthly geometric mean of < 200 cfu/100mL • Single sample maximum of < 800 cfu/100mL	Submit MORs to DEQ
	Chlorine Disinfection (daily)	Free available chlorine residual at the POE to the distribution system and following any subsequent storage or treatment shall be greater than or equal to 0.20 ppm **OR** Combined chlorine residual at the POE to the distribution system and following any subsequent storage or treatment shall be greater than or equal to 0.50 mg/L	
	Dissolved Oxygen (weekly)	Greater than 2.0 mg/L	
5	None		Maintain MORs On-site

[a] From Title 252, Chapter 627, Appendix A.
[b] The daily mean operating filter effluent turbidity (continuously monitored) is calculated as the average of turbidity measures at ≤ 1.2 hour intervals over 24 hours, and must be reported monthly.
[c] The maximum 24 hour turbidity must be based on highest measure from continuous monitoring taken at ≤ 1.2 hour intervals over 24 hours.

Sulphur WWTP Effluent Flows and Water Quality Data

The Sulphur WWTP is an activated sludge SBR facility. The general treatment process includes: headworks; flow equalization; two feed/equalization (EQ) lift stations; three SBR basins; chlorine disinfection; post equalization; post aeration; effluent flow measurement; effluent lift station; waste-activated sludge holding; two digesters; and sludge drying beds. A process flow diagram of the Sulphur WWTP is included in Appendix A. Currently, treated wastewater effluent is pumped and discharged to a tributary of the Washita River. The permitted design capacity (peak month) of the WWTP is 1.5 mgd (1,680 acre-feet/year).

In order to evaluate the wastewater effluent flows and water quality data, Reclamation analyzed Monthly Operations Reports (MORs) from March 1, 2013 through March 31, 2014 for the WWTP. These reports include influent and effluent flow rates, as well as raw influent and treated effluent water quality data that is required as part of their operating permit. Table 6 summarizes the flow and water quality data for the specified 13-month period.

Table 6. Sulphur WWTP – Summary of Flows and Water Quality Data – March 1, 2013 through March 31, 2014. [a]

Statistical Data	Flows		Raw Wastewater				Treated Effluent									
	Influent (mgd)	Effluent (mgd)	Temperature (ºC)	pH	Grit (ft^3/day)	Settleable Solids (mL/L)	Temperature (ºC)	pH	Dissolved Oxygen (mg/L	Settleable Solids (mL/L)	TSS (mg/L)	TSS (lbs/day)	BOD 5-day @ 20ºC) (lbs/day)	Final Ammonia (mg/L)	Final Ammonia (lbs/day)	Cl_2 (mg/L)
Data Points	396	396	396	396	365	396	396	396	396	22	22	22	22	66	39	396
Min	0.10	0.18	14	0.5	1	14	7.0	6.7	-	2.2	10.1	2.5	9.4	0.00	0.07	-
10th Perc.	0.35	0.46	17	1	5	15	7.2	7.4	-	3.3	14.9	2.5	9.9	0.04	0.21	-
25th Perc.	0.40	0.52	18	1	7	16	7.3	7.6	-	4.2	18.7	2.8	13.5	0.07	0.33	-
Median	0.46	0.55	20	1	9	20	7.3	8.0	-	4.6	22.3	3.0	15.4	0.13	0.47	-
Mean	***0.50***	***0.63***	***19***	***1.1***	***8.4***	***20***	***7.3***	***8.0***	***>0.1***	***4.5***	***24.4***	***3.1***	***15.7***	***0.17***	***0.68***	***BDL***
75th Perc.	0.53	0.64	20	1	10	22	7.4	8.5	-	5.0	27.9	3.2	17.6	0.21	0.74	-
90th Perc.	0.66	0.80	21	1	11	23	7.5	8.7	-	5.4	36.8	3.4	22.4	0.35	1.25	-
95th Perc.	0.83	1.08	21	1	12	23	7.5	8.8	-	6.2	40.2	3.4	23.0	0.40	1.54	-
Max	1.91	2.21	23	12	18	23	7.7	9.4	-	6.2	57.5	4.6	24.8	0.97	3.80	-

[a] Data provided by the Sulphur City Officials on May 23, 2014.

As shown in Table 6, the current average annual effluent flow rate that is available for potential wastewater effluent reuse is approximately 0.63 mgd (706 acre-feet/year). The treated water quality data included key parameters such as pH, dissolved oxygen (DO), total suspended solids (TSS), biochemical oxygen demand (BOD), and ammonia. However, turbidity, nutrients (nitrogen/phosphorus) and fecal coliform data were not provided. Additional sampling would be required for a more detailed analysis of treated effluent quality with regards to the limits identified in Table 5.

Sulphur WWTP Wastewater Reuse – Conclusions

As previously noted, the current average annual effluent flow rate that is available for potential wastewater effluent reuse is approximately 0.63 mgd (706 acre-feet/year). Based on review of the State of Oklahoma Title 252 DEQ Rules and Regulations and a brief analysis of the existing WWTP process and effluent water quality data, the following conclusions can be made with regards to potential direct non-potable reuse of treated effluent in Sulphur:

1. ***Category 2 – Not feasible under existing conditions without WWTP improvements***
   The Sulphur WWTP effluent cannot be utilized for Category 2 reuse at this time because of the absence of a coagulation/filtration process, which is required under regulations. Should consideration be made towards adding a coagulation/filtration treatment process to the WWTP, consultation with DEQ is encouraged because the regulations appear to be evolving regarding which technologies may be allowable. Turbidimeter also would need to be installed. In addition to these requirements, the following evaluations would be necessary:
   - A detailed evaluation of the existing WWTP's nutrient removal capabilities would be required to determine if the existing treatment process is capable of removing

nitrogen and phosphorus to acceptable levels established in Title 252, Chapter 656-16-3.

- A detailed evaluation of plant hydraulics and site conditions would be required to determine the feasibility of incorporating these processes into the existing facility.
- A further evaluation of the existing chlorine disinfection system would be required to ensure that the chlorine residuals required at the POE as shown in Table 3 can be met. The proposed modifications also include standards for implementation of sodium hypochlorite and ozone disinfection in the disinfection standards of subchapter 627-21.

2. ***Category 3 – Feasible pending further evaluation of turbidity, nutrients (nitrogen/phosphorus) and fecal coliform data removal, as well as the chlorine disinfection system***
   - As shown in Table 4, the maximum BOD during the 13-month period from March 1, 2013 through March 31, 2014 was 4.6 mg/L, which is well below the 20 mg/L limit established in Table 3.
   - Additional evaluation of the nutrient removal capabilities of the existing facility would be required to determine if the SBR process is capable of removing nitrogen and phosphorus to acceptable levels established in Title 252, Chapter 656-16-3.
   - Turbidity and fecal coliform data were not provided. Additional sampling would be required for a more detailed analysis of treated effluent quality with regards to the limits identified in Table 5.
   - A further evaluation of the existing chlorine disinfection system would be required to ensure that the chlorine residuals required at the POE as shown in Table 3 can be met. The proposed modifications also include standards for implementation of sodium hypochlorite and ozone disinfection in the disinfection standards of subchapter 627-21.

3. ***Category 4 – Feasible pending further evaluation of the chlorine disinfection system***
   - As shown in Table 4, the minimum DO during the 13-month period from March 1, 2013 through March 31, 2014 was 6.7 mg/L, which is well above the 2.0 mg/L limit established in Table 3.
   - A further evaluation of the existing chlorine disinfection system would be required to ensure that the chlorine residuals required at the POE as shown in Table 3 can be met. The proposed modifications also include standards for implementation of sodium hypochlorite and ozone disinfection in the disinfection standards of subchapter 627-21.

4. ***Category 5 – Feasible under existing conditions***
   - Under existing conditions, treated effluent from the Sulphur WWTP could be utilized for Category 5 wastewater reuse with no improvements to the existing facility.

5.

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WATER REUSE MARKET AND PRELIMINARY INFRASTRUCTURE ASSESSMENT

The purpose of this chapter is to provide the Chickasaw Nation and Sulphur with a preliminary market assessment of recycled water customers located within the city and associated preliminary infrastructure. This section is divided into two sections to describe: (1) Category 3 reuse applications, which identify customers that could be serviced using the existing WWTP effluent; and (2) Combined Category 2 and 3 reuse applications, which identifies customers that could be serviced with additional WWTP upgrades.

Sulphur is the county seat of Murray County, Oklahoma. The 2010 Census Bureau data shows that Sulphur area consists of 7.0 square miles with a population of 4,929, which consists of 1,877 households, 1,244 families, and 2,220 housing units. Several large tourist attractions draw visitors to Sulphur each year, which support greater local economic activity, development, and increase water use. The Chickasaw National Recreation Area (CNRA), administered by the National Park Service, is a major tourist destination in the southern area of the City. Although it is among the smallest parks in the National Park System, the CNRA has averaged about 1.28 million recreation visitors annually over the last ten years (National Park Service, 2014). The Chickasaw Cultural Center, located southwest of Sulphur, opened in the summer of 2010 and is another heavily visited destination in the area, with an estimated 62,000 visitors in 2013 and 91,000 visitors in Fiscal Year 2014 (Chickasaw Nation, 2014). Another large attraction is the Artesian Casino and Hotel that opened in August 2013. More than 51,000 guests have stayed at the hotel since it opened, representing an 84% occupancy rate (Chickasaw Nation, 2014).

A variety of other public and commercial goods and services providers are located in the area which support economic activities and are a source of water demands. These goods and services include public schools, health and medical related services, a golf course, concrete production, housing, and many other retail and service activities. The following sections provide an evaluation of the potential demand for recycled water supplies in the Sulphur area based on estimated water use by category of use. End water use for existing water users are evaluated using 2013 billing data, as well as data from studies that correlate end water use as a percentage of total use for commercial, institutional, and residential water users.

Future growth and recycled water demands also were analyzed through 2060.

Existing Water Customers and Potential Category 3 Water Reuse Opportunities

Sulphur water billing data from 2013 was used to evaluate water demands by sector and end use. The billing data showed a total non-residential use of about 80.5 million gallons for the year. This includes two accounts marked as residential which represent a strip mall and a laundromat. The billing data were sorted in order of water use, high to low, and the top 20 water customers were identified to represent a targeted group that may have the greatest potential for water reuse. The top 20 water customers accounted for about 83% of non-residential water use. These customers and their 2013 water uses are listed in Table 7.

Table 7. Sulphur's top 20 water use customers based on 2013 billing records.

Rank	Top Water Customers	2013 Total Water Use (gallons/year)
1	Chickasaw Cultural Center	12,675,000
2	Sulphur Public Schools	9,623,000
3	Chickasaw National Recreation Area	9,607,000
4	Artesian Hotel and Casino	7,000,000
5	Nursing Home	3,387,000
6	Chickasaw Telecommunications Warehouse	3,320,000
7	Dolese Brothers Company (Cement mixing)	2,367,000
8	Artesian Nursing Home	2,119,000
9	Sulphur Hills Golf Course	1,969,000
10	Wal-Mart Super Center (Includes irrigation)	1,536,000
11	Sulphur Terrace Apartments	1,509,000
12	Coin Operated Laundry	1,475,000
13	Oklahoma Veteran's Center	1,444,000
14	Murray County Court House and Jail	1,419,000
15	Chickasaw Housing	1,354,000
16	Arbuckle Memorial Hospital	1,153,000
17	Super 8	1,067,000
18	Strip Mall	877,000
19	Bulldog Auto Spa	826,000
20	Chickasaw Nation Housing Division	798,000

Information on the specific types of water use among the top 20 customers was generally not provided in the 2013 billing data. Landscape irrigation was specifically identified in the billing data for the Chickasaw Cultural Center and for the Wal-Mart Super Center, and additional information was obtained from Sulphur officials regarding irrigation-specific accounts for Sulphur Public Schools, Arbuckle Memorial Hospital, the Sulphur Hills Golf Course, and Pick of the Day garden center. For the most part, specific end uses, such as the percent of water use allocated towards irrigation versus fire control, were not known. For the purposes of this analysis, it was assumed that no fire protection water (Category 2) is included. Therefore, for this assessment, water reuse potential was extrapolated based on end use patterns documented within three studies that provide estimates and percentages of reuse based on business sectors' previous experience. The first study, titled "Commercial and Institutional End Uses of Water " (CIEUW) published by the American Water Works Association (Dziegielewski, Et al., 2000), analyzed the primary water users and types of water use based on previous studies and on their analysis of samples of water billing data from five large cities in the southwestern part of the U.S. The second study, titled "Waste Not, Want Not: The Potential for Urban Water Conservation in California", provides an analysis of potential water conservation in California from the Pacific Institute (Gleick, et al., 2003). The third study, titled "Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program", provides an analysis of water use in the commercial and institutional sector for use in the United States Environmental Protection Agency WaterSense Program (EPA, 2009). Table 8 provides a summary of the three studies' estimates of landscaping water use as a percentage of total use by sector. For customers lacking information on the specific types of water use, water reuse potential was calculated by averaging the percentages of total water use attributable to each sector. Table 9 summarizes the results when the averages are applied to Sulphur's top 20 water customers. Details are provided below.

Table 8. Percentage of total water use attributable to landscape irrigation, based on three studies evaluating water uses across the commercial sector.

Commercial Sector	Study 1[a]	Study 2[b]	Study 3[c]	Average percentage
	(%)			
Hotels	22	10	16	16
Laundries	Na	-	-	-
Schools (K–12)	-	72	-	72
Schools (All)	37	-	28	32
Schools (Other)	-	61	-	61
Hospitals	9	16	7	11
Office Buildings	20	38	22	27
Restaurants	4	6	4	4.5
Car Washes	-	-	-	-
Retail (Non-Grocery)	-	38	-	38
Grocery	-	3	-	3

[a] Source: Dziegielewski, et al. "Commercial and Institutional End Uses of Water. AWWA Research Foundation, Denver, CO. 2000.

[b] Source: Gleick, et al. "Waste Not, Want Not: The Potential for Urban Water Conservation in California." The Pacific Institute, Oakland, CA. Appendix E. November 2003

[c] "Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program." August 2009.

Table 9. Estimated water reuse potential for Sulphur's top 20 water customers.

	Top Water Customers	Commercial Sector[a]	Total Water Uses (gallons)[b]	Potential Category 3 Reuse	
				(%)	(gallons)
1	Chickasaw Cultural Center	-	12,675,000	27	3,358,880
2	Sulphur Public Schools	Schools (All)	9,623,000[c]	32	1,808,570
3	Chickasaw National Recreation Area	-	9,607,000	-	0
4	Artesian Hotel and Casino	-	7,000,000	-	0
5	Nursing Home	Hospital	3,387,000	11	359,020
6	Telecommunications Warehouse	Office Building	3,320,000	27	886,440
7	Dolese Brothers Company	NA	2,367,000	95	2,248,650
8	Artesian Nursing Home	Hospital	2,119,000	11	224,610
9	Sulphur Hills Golf Course	NA	1,969,000	66	1,299,540
10	Wal-Mart Super Center	-	1,536,000	60	858,000
11	Sulphur Terrace Apartments	Hotel	1,509,000	16	242,950
12	Coin Operated Laundry	-	1,475,000	-	0
13	Oklahoma Veteran's Center	Hospital	1,444,000	11	153,060
14	Murray County Court House and Jail	Hotel	1,419,000	16	228,460
15	Chickasaw Housing	Hotel	1,354,000	16	217,990
16	Arbuckle Memorial Hospital	-	1,153,000	22	248,000
17	Super 8	Hotel	1,067,000	16	171,790
18	Strip Mall	NA	877,000	-	0
19	Bulldog Auto Spa	NA	826,000	-	0
20	Chickasaw Nation Housing Division	Hotel	798,000	16	128,480
	Total	**-**	**65,525,000**	**-**	**12,434,440**

[a] Commercial sectors are only applied when additional information was not provided and when applicable. Not Applicable is denoted by NA.

[b] Total water uses are based on 2013 billing records.

[b] 4,041,000 gallons of this volume was specified for irrigation in the billing data. This is assumed to be made up entirely of public use areas/sports complexes, which requires Category 2 reuse water for irrigation and is excluded from the total when applying the average percentage for landscaping.

Description of top water customers and water reuse assumptions:

1. *Chickasaw Cultural Center* – The Cultural Center sits on large grounds with a complex of multiple buildings, including exhibit centers, office and conference buildings, and a theater. The complex also includes multiple outdoor recreation areas with gardens, water features, and traditional housing exhibits. The Cultural Center reported 2013 use of 2.14 million gallons for sprinklers, 0.81 million gallons for fountain use, and 0.4 million gallons for the gate area. These three uses are categorized as landscape irrigation and represent approximately 27% of total use. Landscape irrigation at the Cultural Center is assumed to be approximately 3.36 million gallons.
2. *Sulphur Public Schools* – The Sulphur Public School District has four facilities. Two accounts in the 2013 billing data were specified for irrigation at Sulphur Public Schools, totaling 4.04 million gallons of use. These uses are assumed to be made up entirely of public use areas/sports complexes, which requires Category 2 reuse water for irrigation and is excluded from the total. The remaining 5.60 million gallons of school use is disaggregated using the average of school landscape irrigation from the three sources previously described. Landscape irrigation is assumed to be 32% of the remaining use. This percentage is applied to the 2013 water use estimates for all school billing accounts because separate use categories are not provided. The school's landscape irrigation with restricted access is assumed to be approximately 1.81 million gallons.
3. *Chickasaw National Recreation Area (CNRA)* – At this time CNRA does not use any water for landscape irrigation and no other Category 3 water uses were identified through conversations with CNRA.
4. *Artesian Hotel and Casino* – Although end water use percentages were identified for hotels and could be applied for this hotel and casino, information from Sulphur officials indicated that no water from the billed account was used for landscape irrigation.
5. *Nursing Home* – The hospital sector of end water use from Table 8 is applied to nursing homes. Landscape irrigation is assumed to be 11%, approximately 0.36 million gallons.
6. *Chickasaw Telecommunications Warehouse* – The office buildings commercial sector of end use was applied to the telephone warehouse since it is a part of Chickasaw Telecommunications Services. Therefore the end use percentage of 27% water assumed for landscape irrigation.
7. *Dolese Brothers Company* – Analyses indicate that the use of recycled water for mixing concrete does not have an adverse effect on the quality or performance of the final product (Chini and Mbwambo, 1996; Lobo and Mullings, 2003). Therefore, it is assumed that the concrete mixing portion of water demand could be met using recycled water supplies. The end use water percentages in Table 8 do not include manufacturing activities. The information presented in the CIEUW for car washes indicated 5% of total end use was attributable to restrooms. Similarly it is assumed that the remaining 95% of total end uses would consist of Category 3 uses such as concrete mixing, dust control, and aggregate washing/sieving. The assumed Category 3 uses are approximately 5.9 million gallons.

8. *Artesian Nursing Home* – The hospital sector of end water use from Table 8 is applied to nursing homes. Landscape irrigation is assumed to be 11%, approximately 0.25 million gallons.
9. *Sulphur Hills Golf Course* – The Sulphur Hills Golf Course represents an important potential demand for recycled water. A study by the Golf Course Superintendents Association of America (2009) indicated that approximately 12% of golf courses nationally use recycled water as a source for irrigation. The percentage is much higher in the southwestern U.S. (37%) and southeastern U.S. (24%). For those that did not use recycled water, the leading reason for not using recycled supplies was a lack of a recycled water source (53%) and a lack of infrastructure to deliver available water (13%). For the purposes of this analysis it is assumed that if the unavailability of recycled water and lack of infrastructure barriers were removed, recycled water would be acceptable to supply 66% of golf course water irrigation supplies. Landscape irrigation at the golf course is assumed to be approximately 1.3 million gallons.
10. *Wal-Mart Super Center* – The billing data included 858,000 gallons per year for Wal-Mart Super Center's landscape irrigation use.
11. *Sulphur Terrace Apartments* – Water uses for apartments are assumed to be the same as for hotels. Table 8 indicates 16% of water use is for landscape irrigation. Landscape irrigation at this apartment is assumed to be approximately 0.24 million gallons.
12. *Coin Operated Laundry* – Oklahoma water reuse regulations do not allow recycled water for laundry use and it is assumed that none of the existing water use is for landscape irrigation.
13. *Oklahoma Veteran's Center* – The percentages for hospitals shown in Table 8 are used for the Oklahoma Veteran's Center. Landscape irrigation is assumed to be 11%, approximately 0.15 million gallons.
14. *Murray County Courthouse and Jail* – A category of use for the courthouse and jail is not available. However, since the use includes housing the end use percentages used for apartments is used for this category. Landscape irrigation is assumed to be 16.1%, approximately 0.23 million gallons.
15. *Chickasaw Housing* – Water use for apartments is assumed to be the same as for hotels. Table 8 indicates 16% of water use is for landscape irrigation. Landscape irrigation at this apartment is assumed to be approximately 0.22 million gallons.
16. *Arbuckle Memorial Hospital* – The 2013 billing data for Arbuckle Memorial Hospital indicates 248,000 gallons were used for a landscape irrigation account and 905,000 gallons were used for an account for other purposes. Landscape irrigation accounts for 22% of total hospital water use.
17. *Super 8* – Water uses for hotels from Table 8 indicates 16% of water use is for landscape irrigation. Landscape irrigation at this hotel is assumed to be approximately 0.17 million gallons.
18. *Broadway Street Strip Mall* –The retail non-grocery category of water use from Table 8 indicates 38% of water use is used landscape irrigation. However, account information from the Sulphur City Officials indicated none of the strip mall water account was used for landscape irrigation.

19. *Bulldog Auto Spa* - This property includes one automatic car wash as well as four self-service car washes. Oklahoma water reuse regulations do not allow Category 3 recycled water for carwashes and it is assumed that none of the existing water use is for landscape irrigation.
20. *Chickasaw Nation Housing Division* – Water uses for apartments are assumed to be the same as for hotels. Table 8 indicates 16% of water use is for landscape irrigation. Landscape irrigation at this apartment is assumed to be approximately 0.13 million gallons.

Figure 5 shows a map of the top water customers with potential for Category 3 water reuse and the associated volumes.

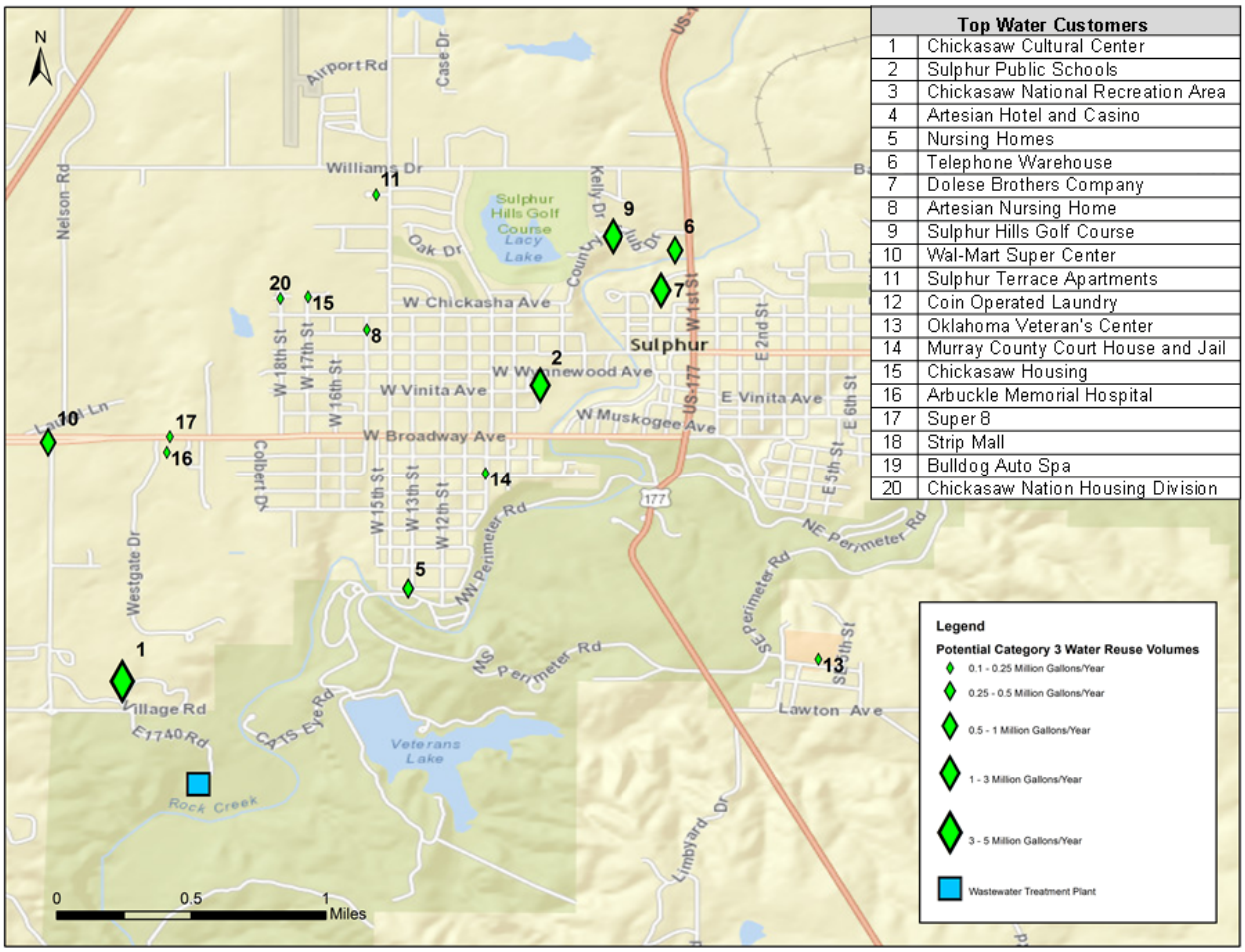

Figure 5. Top water customers and their potential Category 3 reuse volume ranges.

Proposed Conveyance Infrastructure for Category 3 Customers

Although a number of potential routes exist to pump the water from the WWTP to Sulphur, the shortest path that avoids buildings and minimizes river and stream crossings is illustrated in Figure 6. This potential alignment was used to determine the feet of pipe required to convey reuse water from the WWTP to each of the top 20 Category 3 customers, respectively. The pipeline distances were combined with the individual reuse potential to calculate a unit benefit in gallons per foot. The unit benefit of each customer was subsequently ranked for the purposes of phasing the infrastructure in a manner that maximizes the benefit to cost ratio.

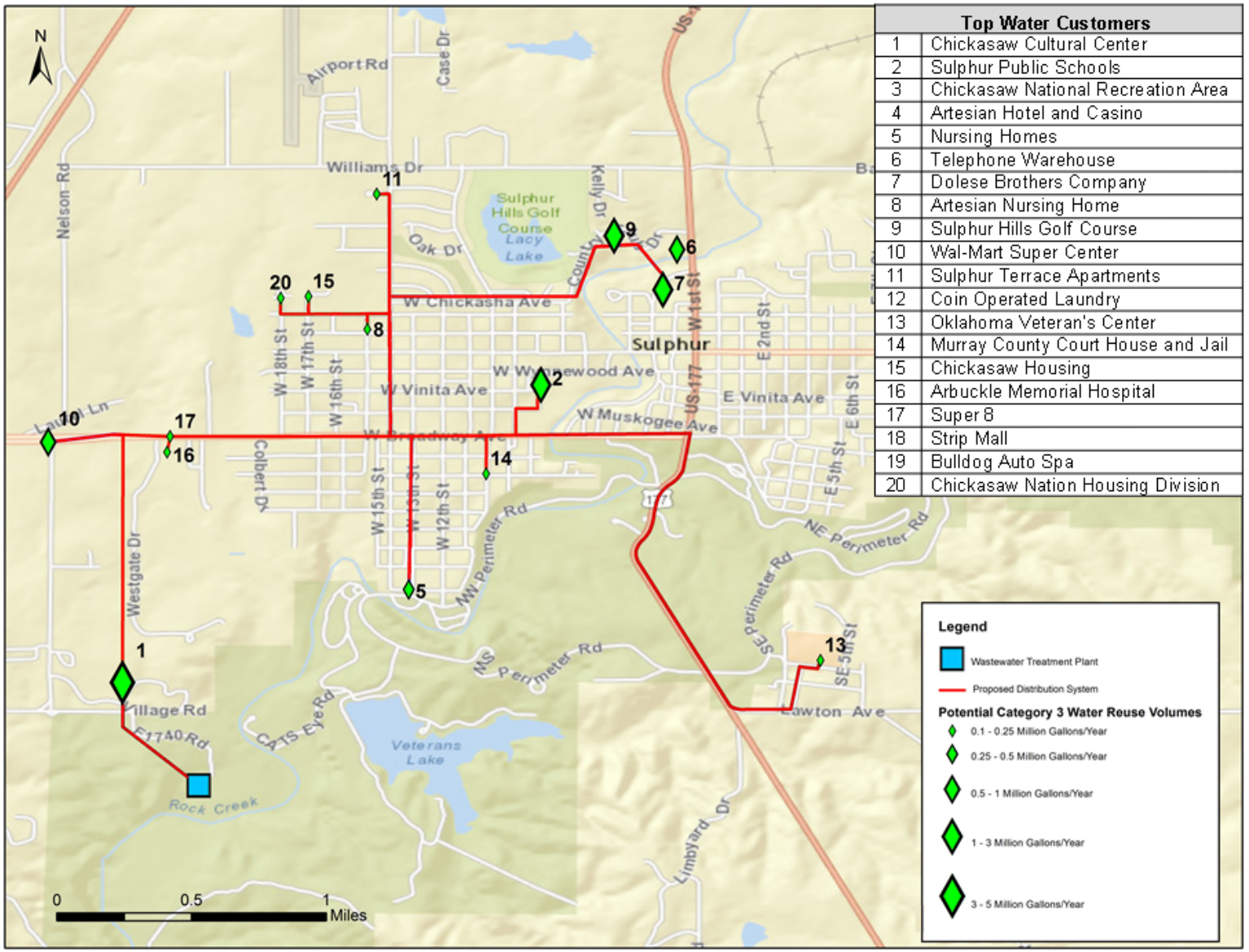

Figure 6. The shortest potential distribution system to each customer, along with their range of Category 3 water reuse volume.

Table 10. The ranking of Category 3 customers based on the estimated Category 3 reuse benefit per pipe required for Sulphur's top 20 water customers.

Top Water Customers		Potential Category 3 Uses (gallons)	Pipe Required from WWTP (ft)	Unit Benefit (gal/ft)	Ranking
1	Chickasaw Cultural Center	3,358,880	2,400	1,400	1
2	Sulphur Public Schools	1,808,570	15,370	118	2
3	Chickasaw National Recreation Area	0	-	-	-
4	Artesian Hotel and Casino	0	-	-	-
5	Nursing Home	359,020	15,160	24	8
6	Telecommunications Warehouse	886,440	19,920	45	6
7	Dolese Brothers Company	2,248,650	20,670	109	3
8	Artesian Nursing Home	224,610	14,930	15	11
9	Sulphur Hills Golf Course	1,299,540	18,400	71	5
10	Wal-Mart Super Center	858,000	8,840	97	4
11	Sulphur Terrace Apartments	242,950	16,710	15	12
12	Coin Operated Laundry	0	-	-	-
13	Oklahoma Veteran's Center	153,060	24,530	6	15
14	Murray County Court House and Jail	228,460	13,950	16	10
15	Chickasaw Housing	217,990	16,070	14	13
16	Arbuckle Memorial Hospital	248,000	8,980	28	7
17	Super 8	171,790	8,780	20	9
18	Strip Mall	0	-	-	-
19	Bulldog Auto Spa	0	-	-	-
20	Chickasaw Nation Housing Division	128,480	16,430	8	14

Based on Table 10, six of the 20 customers appear to have the largest unit benefits relative to the remaining customers, and are thus considered "priority customers". Figure 7 illustrates the proposed distribution system to these priority Category 3 customers. Customers that are located along the route or adjacent to a priority customer were included in the analysis to determine the most cost effective phases for implementation. Segment A would convey water to the Cultural Center because it is ranked as the highest priority. Segment B would convey water to Sulphur Public Schools and Wal-Mart, the second and fourth ranked users, and other adjacent customers. Segment B is also anticipated to allow additional water reuse opportunities along Broadway Avenue that are not specified in the top 20 water customers. Segment C prioritizes the next three top users located in the northeast part of town.

To ensure appropriate sizing of infrastructure, daily and seasonal peaking factors were applied for irrigation and concrete activities (concrete mixing, dust control, and aggregate washing/sieving).

- It was assumed that recycled water use for irrigation would occur over a 10-hour period at night. Therefore, a daily peaking factor of 2.4 (24/10) was applied to the 23,900 gpd average flow for irrigation. Similarly, a peaking factor of 3 (24/8) was applied for concrete activities since these activities would only occur during working hours.

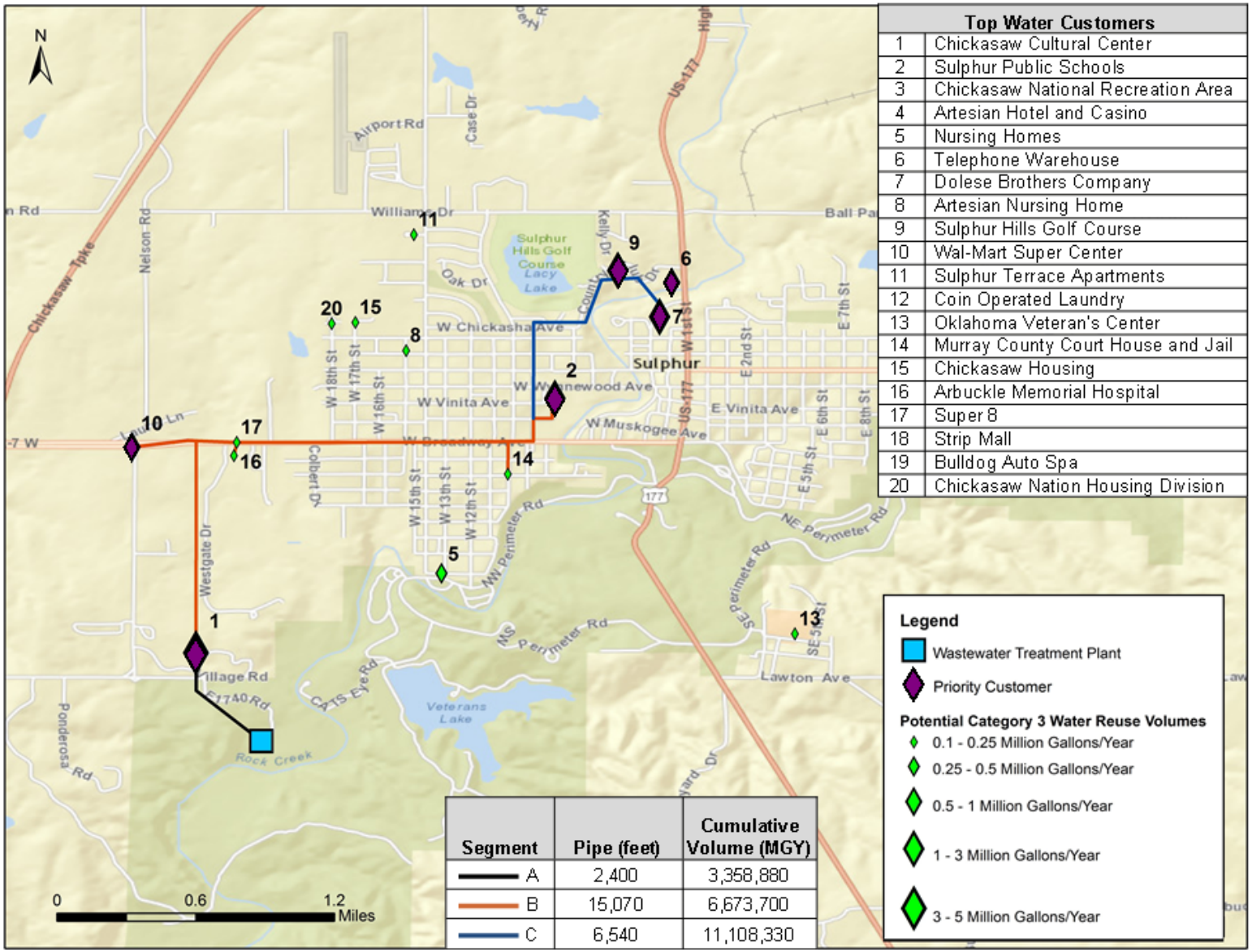

Figure 7. Proposed pipeline segments to distribute water to priority Category 3 customers, along with pipe required and expected reuse volume.

- Seasonal peaking factors were also applied based on the monthly use variations. Three entities were identified with separate irrigation billing data and used to determine monthly use variations for Sulphur: Chickasaw Cultural Center, Sulphur-Davis Golf Course, and Wal-Mart. Water use identified for these three entities primarily occurred during four to five summer months. An average peaking factor of 2.6 (12/4.5) was calculated and applied as a seasonal peaking factor for irrigation uses. Similarly, water use for Dolese Concrete Company occurred year round, but the highest water use occurred over seven months. An average peaking factor of 1.6 (12/7.69) was calculated for Dolese and applied as a seasonal peaking factor.

Table 11 provides a summary of the peaking factors and calculated peak use. The daily total peak demand for potential Category 3 water reuses is 151,000 gpd. Infrastructure was sized based on the daily total peak demand and a decadal growth rate of eight percent through 2060, consistent with the population projections, to allow for future growth. This generates at total peak demand for potential Category 3 water reuse of 221,000 gpd in 2060.

Table 11. Summary of irrigation and concrete (concrete mixing, dust control, and aggregate washing/sieving) demands and peaking factors assumptions.

	Demand		**Daily Peak**	**Seasonal**	**Peak Demand**
Potential Category 3 Uses	(MGY)	(gpd)	**Factor**	**Peak Factor**	(gpd)
Irrigation	8.74	23,900	2.4	2.6	151,000
Concrete	2.37	6,500	3	1.6	30,000
2060 Irrigation	12.84	35,100	2.4	2.6	221,000

It was assumed that additional storage would not be needed to meet peak demands because the peak demand is less than half of the daily flow rate at the WWTP. However, additional pumps would be required to meet the total peak demands and future growth. The pumps were sized based on a hydraulic analysis and costs were developed and included in estimates for Phases A-B and A-C. Table 12 provides a summary of the cumulative estimated costs of these phases. The estimated capital cost for these three segments is approximately $592,000. .

Table 12. Summary of the cumulative estimated costs of the three proposed Category 3 distribution system phases.

Distribution Summary	**Proposed Category 3 Phases**		
Segment	A	A-B	A-C
Pipe (feet)	2,400	17,470	24,010
Volume (gallons /year)	3,358,880	6,673,700	11,108,330
Total Capital Cost	$57,000	$437,000	$592,000
Present Worth of O&M Cost	$27,000	$302,000	$374,000
Total Capital and O&M Cost	**$84,000**	**$739,000**	**$966,000**
Annualized Capital Cost	$3,300	$25,300	$34,200
Annual O&M	$1,200	$13,286	$16,486
Total Annual Cost	**$4,500**	**$38,586**	**$50,686**
Total Annual Cost per 1,000 gallons	**$1.34**	**$5.78**	**$4.56**
Total Annual Cost per acre-foot	**$437**	**$1,884**	**$1,487**

Estimated End Use for Remaining Water Users and Potential Recycled Demand

The top 20 water users represent about 83% of the total non-residential demands. The remaining sectors of demand are categorized as restaurants, churches, grocery stores, and miscellaneous retail and services. The information in Table 13 provides reuse estimates for these customers, which total about 3.4 million gallons per year. This small volume could be readily conveyed within the infrastructure previously identified above for the top 20 users at no additional cost.

Table 13. Total water use estimates, percentage of uses estimated for Category 3 landscape irrigation, as well as estimated volume for all users not included in the top 20 customers.

		Potential Category 3 Uses	
Sector	**2013 Total Use**	(%)	(gallons)
Churches	717,000	27	191,430
Restaurants	4,487,000	4.5	201,920
Grocery Stores	603,000	3.0	18,090
Miscellaneous	7,876,000	38	2,992,880
Total	**13,686,000**	**-**	**3,404,320**

Existing Water Customers and Potential Category 2 Reuse Opportunities

Category 2 water reuse was assessed for the top 20 water customers using a similar methodology to Category 3 by utilizing water reuse records and extrapolations based on studies that evaluate reuse potential as a percentage of total use. Based on DEQ OAC Chapter 656, Subchapter 27, as shown in Table 2, the specific allowable water uses for Category 2 reuse are plumbing (i.e, toilet flushing), HVAC (i.e., cooling/heating), automatic carwash, and irrigation of sports complexes where human contact is likely. These four specific allowable uses are described below. Allowable uses also include the uses previously described that are allowable under Category 3 treatment (i.e., restricted-use irrigation and concrete mixing).

- **Plumbing:** Oklahoma regulations allow the use of Category 2 recycled water for restroom water use for toilet/urinal flushing. Establishments would be required to dual plumb facilities to provide separate potable and nonpotable water lines in restrooms and post appropriate signs. Because dual-plumbing systems are so site specific, this assessment does not include such systems in its preliminary design or cost estimates provided below.
- **HVAC:** Oklahoma regulations allow the use of Category 2 recycled water for some types of cooling and Category 3 reclaimed water for industrial cooling. Regulations require that systems be closed looped; these systems generally do not rely on evaporation and require newer technology that is more water efficient. Additional site-specific research is needed to evaluate the types of cooling technology each facility uses and the potential for using recycled water to satisfy that demand. Many large establishments have cooling towers which use a significant amount of water, such as those found in supermarkets and grocery stores that require refrigeration. Cooling towers are also found in large offices, hotels, and high schools.
- **Automatic Carwash:** Oklahoma regulations allow the use of Category 2 recycled water for automatic carwashes. Carwashes would be required to connect only the automatic stations to these water lines and dual plumbing could be required to some extent.

- **Irrigation:** Oklahoma regulations allow the use of Category 2 recycled water for spray or drip irrigation on public access landscapes and public use areas/sports complexes, including unrestricted access golf courses. Sulphur Public Schools was identified as the only establishment with public use areas/sports complexes where Category 2 recycled water would be required. Because Category 2 treatment is sufficient to meet Category 3 irrigation and concrete use, all values provided below include both Category 2 and 3.

Similarly for this assessment, water reuse potential was extrapolated based on end use patterns documented within the three studies previously described in the Category 3 Section: AWWA, 2009; Gleick, et al., 2003; and EPA, 2009. Table 14 provides a summary of the average percentage of water use attributed to plumbing, HVAC, and irrigation as a percentage of total use by sector based on these three studies. For customers lacking information on the specific types of water use, water reuse potential was calculated by averaging the percentages of total water use attributable to each sector. Table 15 summarizes the results when the averages are applied to Sulphur's top 20 water customers. Details are provided below.

Table 14. Percentage of total water use attributed to plumbing, HVAC, and landscape irrigation, based on three studies evaluating water use across the commercial sector[a-c].

Commercial Sector	Plumbing	HVAC	Irrigation
Hotels	16	9.5	16
Laundries	2.5	5.6	-
Schools (K–12)	13	-	72
Schools (All)	28	7.7	32
Schools (Other)	13	-	61
Hospitals	18	26	11
Office buildings	21	28	27
Restaurants	20	1.6	4.5
Car Washes	3.2	-	-
Retail (Non-Grocery)	16	21	38
Retail (Grocery)	11	49	3

[a] Source: Dziegielewski, et al. "Commercial and Institutional End Uses of Water. AWWA Research Foundation, Denver, CO. 2000.

[b] Source: Gleick, et al. "Waste Not, Want Not: The Potential for Urban Water Conservation in California." The Pacific Institute, Oakland, CA. Appendix E. November 2003

[c] "Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program." August 2009.

Table 15. Estimated water reuse potential for Sulphur's top 20 water customers.

	Top Water Customers	Commercial Sector[a]	Total Water Uses (gallons)[b]	Potential Category 2 Reuse (%)[c]				Potential Category 2 Reuse (gallons)[c]
				Plumbing	HVAC	Automatic Carwash	Irrigation	
1	Chickasaw Cultural Center	-	12,675,000	18	14	0	27	7,414,880
2	Sulphur Public Schools	Schools (All)	9,623,000[d]	28	7.7	0	32	7,836,760
3	Chickasaw National Recreation Area	Office Building	9,607,000[e]	21	0	0	0	173,040
4	Artesian Hotel and Casino	Hotel	7,000,000	16	9.5	0	0	1,771,000
5	Nursing Homes	Hospital	3,387,000	18	26	0	11	1,859,460
6	Telecommunications Warehouse	Office Building	3,320,000	21	28	0	27	2,516,560
7	Dolese Brothers Company	NA	2,367,000	0.3	0	0	95	2,324,390
8	Artesian Nursing Home	Hospital	2,119,000	18	26	0	11	1,163,330
9	Sulphur Hills Golf Course	NA	1,969,000	0	0	0	66	1,299,540
10	Wal-Mart Super Center	Retail (Non-Grocery)	1,536,000[f]	26	34	0	56	1,266,830
11	Sulphur Terrace Apartments	Hotel	1,509,000	16	9.5	0	16	624,730
12	Coin Operated Laundry	Laundry	1,475,000	2.5	5.6	0	0	119,480
13	Oklahoma Veteran's Center	Hospital	1,444,000	18	26	0	11	792,760
14	Murray County Court House and Jail	Hotel	1,419,000	16	9.5	0	16	587,467
15	Chickasaw Housing	Hotel	1,354,000	16	9.5	0	16	560,552
16	Arbuckle Memorial Hospital	Hospital	1,153,000[g]	14	20	0	22	550,270
17	Super 8	Hotel	1,067,000	16	9.5	0	16	441,741
18	Strip Mall	Retail (Non-Grocery)	877,000	16	21	0	0	327,998
19	Bulldog Auto Spa	Carwash	826,000[h]	3.2	0	100	0	191,632
20	Chickasaw Nation Housing Division	Hotel	798,000	16	10	0	16	330,374
	Total		**65,525,000**	**-**	**-**	**-**	**-**	**32,152,800**

[a] Commercial sectors are only applied when additional information was not provided and when applicable. Not Applicable is denoted by NA.
[b] Total water uses are based on 2013 billing records.
[c] Also includes category 3 reuses.
[d] 4,041,000 gallons of this volume was specified for irrigation in the billing data. This is assumed to be made up entirely of public use areas/sports complexes, which requires Category 2 reuse water for irrigation and is excluded from the total when applying the average percentage for landscape irrigation.
[e] Percentages are only applies to uses at the CNRA's Travertine Nature Center, this was 824,000 gallons in 2013.
[f] Billing data included irrigation us; therefore, Retail (Non-Grocery) percentages are only applied for plumbing and HVAC.
[g] Percentages are applied relative to reported landscape water use.
[h] Only one of the five carwash stalls for Bulldog Auto Spa is an automatic carwash and can use Category 2 recycled water; therefore, only 165,200 gallons is applicable is assumed.

Description of top water customers and water reuse assumptions:

1. *Chickasaw Cultural Center* – The Cultural Center reported 1.62 million gallons of restroom water use in 2013, which is 13% of total water use. Assuming the proportion of water used for plumbing is 63% (Mayer, et al., 1999), this represents about 8% of total Cultural Center water use. A separate category of water use is included for the theater, which would include water use for plumbing and HVAC. The total theater use for 2013 was 6.19 million gallons. A specific water use category is not provided for theaters in Table 14, but office buildings may be a reasonable proxy for theater use. The average percentage of total use for plumbing is 21% and HVAC is 28%. Applying these percentages to theater water use would result in 1.30 million gallons for plumbing and 1.74 million gallons for HVAC. Therefore, plumbing use for the Cultural Center is estimated to be 18% of total use and HVAC is estimated to be 14% of total water use.
2. *Sulphur Public Schools* –Two accounts in the 2013 billing data were specified for irrigation at Sulphur Public Schools, totaling 4.04 million gallons of use. The remaining 5.58 million gallons of school use is disaggregated using information from Table 14. Table 14 shows that 28% of school water use is used for plumbing and 7.7% is used for HVAC.
3. *Chickasaw National Recreation Area (CNRA)*: A specific water use category is not provided for recreation areas or visitor centers in Table 14. However, similar to theater water use for the Cultural Center, office buildings may be a reasonable proxy for CNRA's Travertine Nature Center. CNRA reported in a conversation with Reclamation on January 6, 2014 that no water is used for HVAC at the center. The average percentage of total use for plumbing is 21% was applied for the water use of 824,000 gallons used at the center.
4. *Artesian Hotel and Casino* – End water use percentages in Table 14 for the hotel category are generally used for the hotel and casino. However, information from the Sulphur City Officials indicated that no water from the billed account was used for landscape irrigation. Therefore, only water for plumbing and HVAC was included in the estimates for potential Category 3 water reuse. Water uses are assumed to be 16% for plumbing and 9.5% for HVAC.
5. *Nursing Home* – The hospital sector of end water use from Table 14 is applied to nursing homes. Water uses are assumed to be 18% for plumbing, 26% for HVAC, and 11% for landscape irrigation.
6. *Chickasaw Telecommunications Warehouse* – The office buildings commercial sector used as a proxy for the warehouse. Therefore the end use percentages applied were 21% for plumbing, 28% for HVAC, and 27% for landscape irrigation.
7. *Dolese Brothers Company* – The end use water percentages in Table 14 do not include manufacturing activities. However, it could be assumed that plumbing water use for a manufacturing type of activity would be similar to a business that does not serve customers in a traditional retail setting, such as a car wash. The information presented in Table 14 for car washes indicated 5% of total end use was attributable to restrooms which translated into 3.2% for plumbing as shown in Table 14. Therefore, only 1.8% of total water use could not be supplied by recycled water and potential recycled water use for concrete was estimated to be 98% of total water use.

8. *Artesian Nursing Home* – The hospital sector of end water use from Table 14 is applied to nursing homes. Water uses are assumed to be 18% for plumbing, 26% for HVAC, and 11% for landscape irrigation.

9. *Sulphur Hills Golf Course* – The Sulphur Hills Golf Course represents an important potential demand for recycled water. A study by the Golf Course Superintendents Association of America (2009) indicated that approximately 12% of golf courses nationally use recycled water as a source for irrigation. The percentage is much higher in the southwestern U.S. (37%) and southeastern U.S. (24%). For those that did not use recycled water, the leading reason for not using recycled supplies was a lack of a recycled water source (53%) and a lack of infrastructure to deliver available water (13%). For the purposes of this analysis it is assumed that if the unavailability of recycled water and lack of infrastructure barriers were removed, recycled water would be acceptable to supply 66% of the golf course water irrigation supplies.

10. *Wal-Mart Super Center* – The billing data included 858,000 gallons per year for Wal-Mart Super Center's irrigation use. Information from Table 14 for retail non-grocery retail activity, excluding landscape irrigation, is used to estimate end uses as a percentage of total use for the non-irrigation account. Non-irrigation end uses represent 62% of total water use for the retail non-grocery sector. Of this percentage 16% represents plumbing and 21% represents HVAC. Therefore, the percentage of total water use for the non-irrigation water use account is 26% for plumbing and 34% for HVAC.

11. *Sulphur Terrace Apartments* – Water uses for apartments are assumed to be the same as for hotels. Table 14 indicates 16% for plumbing, 9.5% for HVAC, and 16% for landscape irrigation.

12. *Coin Operated Laundry* – Oklahoma water reuse regulations do allow recycled water for laundry use. However, the information from Table 14 indicates 2.5% of total laundry sector use is for plumbing and 5.6% is for HVAC. These percentages are used to estimate potential recycled water demand for the laundry sector.

13. *Oklahoma Veteran's Center* – The percentages for hospitals shown in Table 14 are used for the Oklahoma Veteran's Center. End water uses are assumed to be 18% for plumbing, 26% for HVAC, and 11% for landscape irrigation.

14. *Murray County Courthouse and Jail* – A commercial sector category for the courthouse and jail is not available. However, since the use includes housing the end use percentages used for apartments is used for this category. End use is estimated to be 16% for plumbing, 9.5% for HVAC, and 16% for landscape irrigation.

15. *Chickasaw Housing* – Water use for apartments is assumed to be the same as for hotels. Table 14 indicates 16% for plumbing, 9.5% for HVAC, and 16% for landscape irrigation.

16. *Arbuckle Memorial Hospital* – The 2013 billing data for Arbuckle Memorial Hospital indicates 248,000 gallons were used for a landscape irrigation account and 905,000 gallons were used for an account for other purposes. Landscape irrigation accounts for 22% of total hospital water use. Information from Table 14 indicates on average 55% of total water use is attributable to plumbing, HVAC, and landscape irrigation. Using this percentage as the basis for total potential recycled water demand and assuming the relative percentage of end water

use from Table 14 is applicable for plumbing and HVAC, the percentage of total use attributable to plumbing is 14% and 20% is attributable to HVAC.

17. *Super 8* – Water uses for hotels from Table 14 indicates 16% for plumbing, 9.5% for HVAC, and 16% for landscape irrigation.
18. *Broadway Street Strip Mall* –The retail non-grocery category of water use from Table 14 indicates 16% is used for plumbing, 21% is used for HVAC, and 38% is used for landscape irrigation. However, account information from the Sulphur City Officials indicated none of the strip mall water account was used for landscape irrigation. Therefore, only the plumbing and HVAC percentages are applied to strip mall water usage.
19. *Bulldog Auto Spa* - This property includes one automatic car wash as well as four self-service car washes. Category 2 recycled water use applies to only automatic carwashes. It is assumed that one-fifth of water use represents potential recycled water use. The plumbing percentage of 3.2% from Table 14 is applied to the remaining 80%, resulting in a total potential recycled water demand of 23% for the car wash
20. *Chickasaw Nation Housing Division* – Water uses for apartments are assumed to be the same as for hotels. Table 14 indicates 16% for plumbing, 9.5% for HVAC, and 16% for landscape irrigation.

Figure 8 illustrates a map of the top water customers with potential for Category 2 water reuse and the associated volumes.

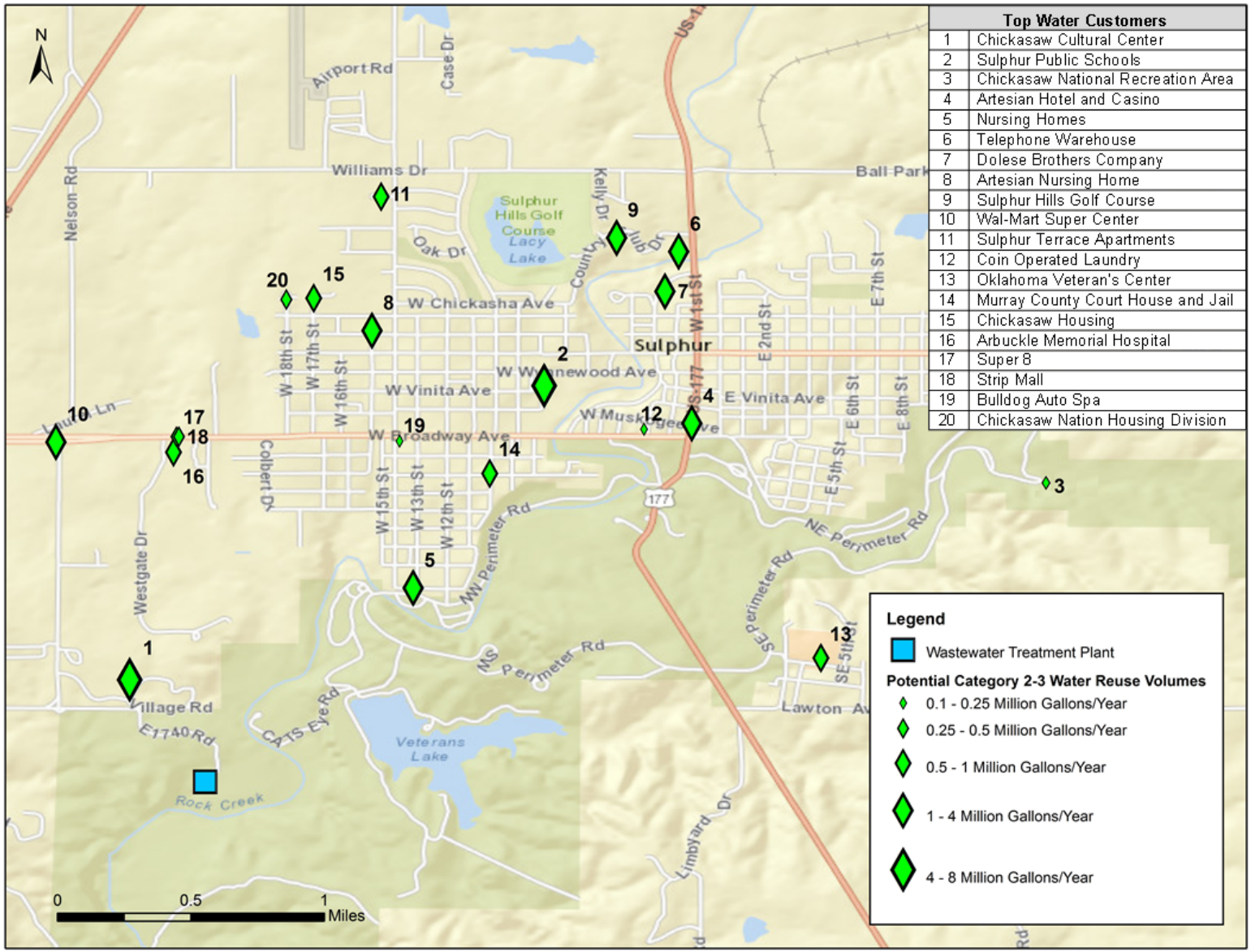

Figure 8. Top water customers and their potential Category 2 water reuse volume ranges. The volumes also include Category 3 uses.

Proposed Conveyance Infrastructure for Category 2 Customers

As previously stated, additional treatment upgrades (i.e., coagulation/filtration) would be required at the WWTP to meet regulations for Category 2 uses. These upgrades would also be sufficient to meet Category 3 use regulations. A packaged coagulation/filtration unit was identified that would meet DEQ regulations; costs for this unit are included in the estimate below. The WWTP would also require online treated effluent turbidimeters, as well as potential improvements to the chlorine disinfection system. However, for this preliminary assessment, the existing chlorine disinfection system is assumed to be sufficient. Details of the WWTP improvements are included in Appendix C and D.

Similar to the previous alternative development, Figure 9 shows the shortest path that avoids buildings and minimizes river and stream crossings. This potential alignment was used to determine the feet of pipe required to convey reuse water from the WWTP to each of the top 20 Category 2 customers, respectively. The pipeline distances were combined with individual reuse potential to calculate a unit benefit in gallons per foot. The unit benefit of each customer was subsequently ranked for the purposes of phasing the infrastructure in a manner that maximizes the benefit to cost ratio. Table 16 provides the ranking. Figure 10 illustrates the proposed distribution system phases.

Table 16. The ranking of Category 2 customers based on the estimated Category 2 reuse benefit per pipe required for Sulphur's top 20 customers. Category 3 uses are included in the estimates.

	Top Water Customers	**Potential Category 2 Uses** (gallons)	**Pipe Required** (feet)	**Unit Benefit** (gallons/ft)	**Ranking**
1	Chickasaw Cultural Center	7,414,880	2,400	3,090	1
2	Sulphur Public Schools	7,836,760	15,370	510	2
3	Chickasaw National Recreation Area	173,040	11,690	15	19
4	Artesian Hotel and Casino	1,771,000	15,460	115	9
5	Nursing Home	1,859,460	8,380	222	5
6	Telecommunications Warehouse	2,516,560	7,950	317	3
7	Dolese Brothers Company	2,324,390	9,660	241	4
8	Artesian Nursing Home	1,163,330	8,090	144	7
9	Sulphur Hills Golf Course	1,299,540	11,650	112	11
10	Wal-Mart Super Center	1,266,830	7,550	168	6
11	Sulphur Terrace Apartments	624,730	6,160	101	12
12	Coin Operated Laundry	119,480	16,160	7	20
13	Oklahoma Veteran's Center	792,760	16,650	48	15
14	Murray County Court House and Jail	587,470	8,420	70	13
15	Chickasaw Housing	560,560	8,970	62	14
16	Arbuckle Memorial Hospital	550,270	4,860	113	10
17	Super 8	441,740	3,690	120	8
18	Strip Mall	328,000	8,720	38	16
19	Bulldog Auto Spa	191,630	11,950	16	18
20	Chickasaw Nation Housing Division	330,370	15,640	21	17

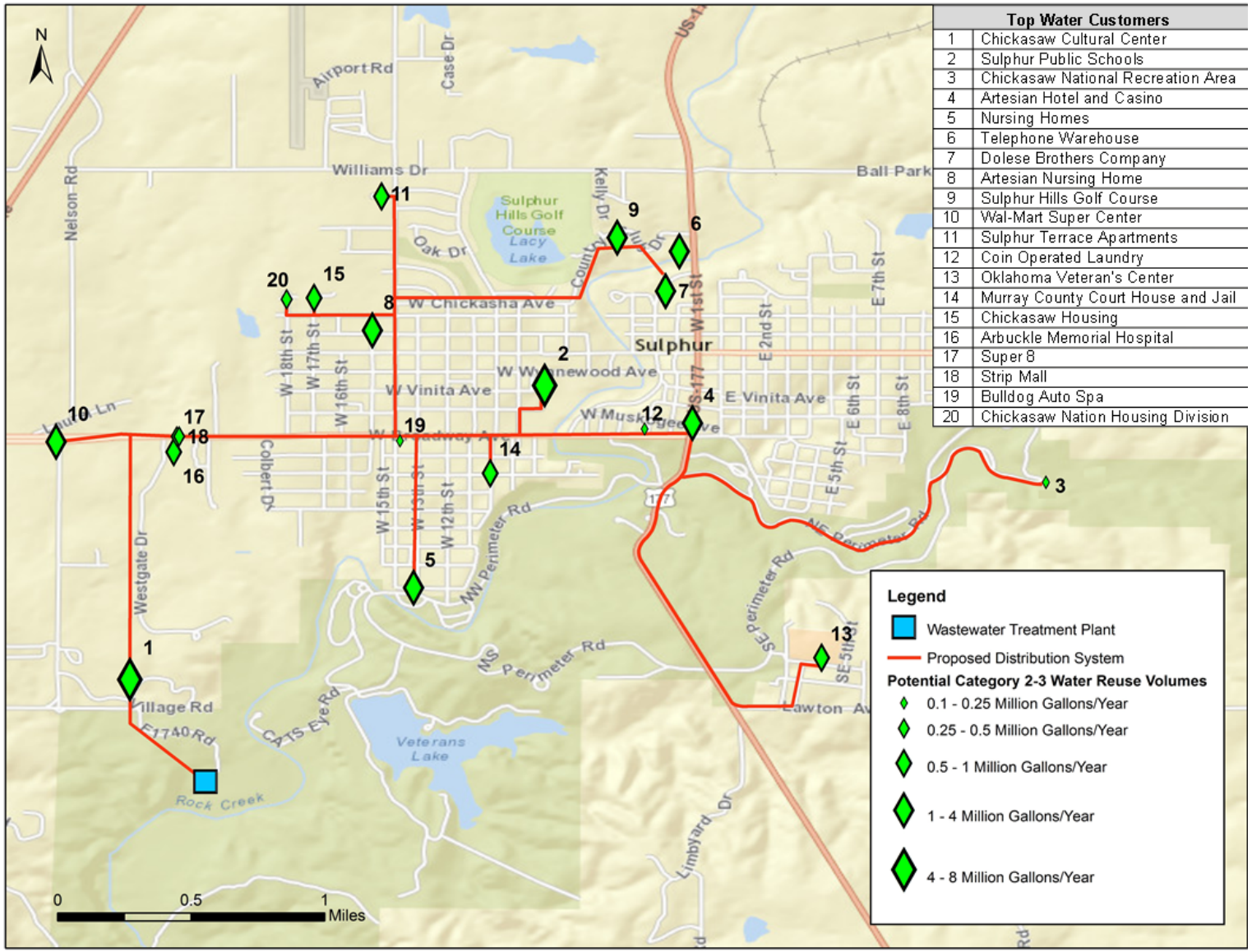

Figure 9. The shortest potential distribution system to each customer, along with their range of Category 2 (and Category 3) water reuse volume.

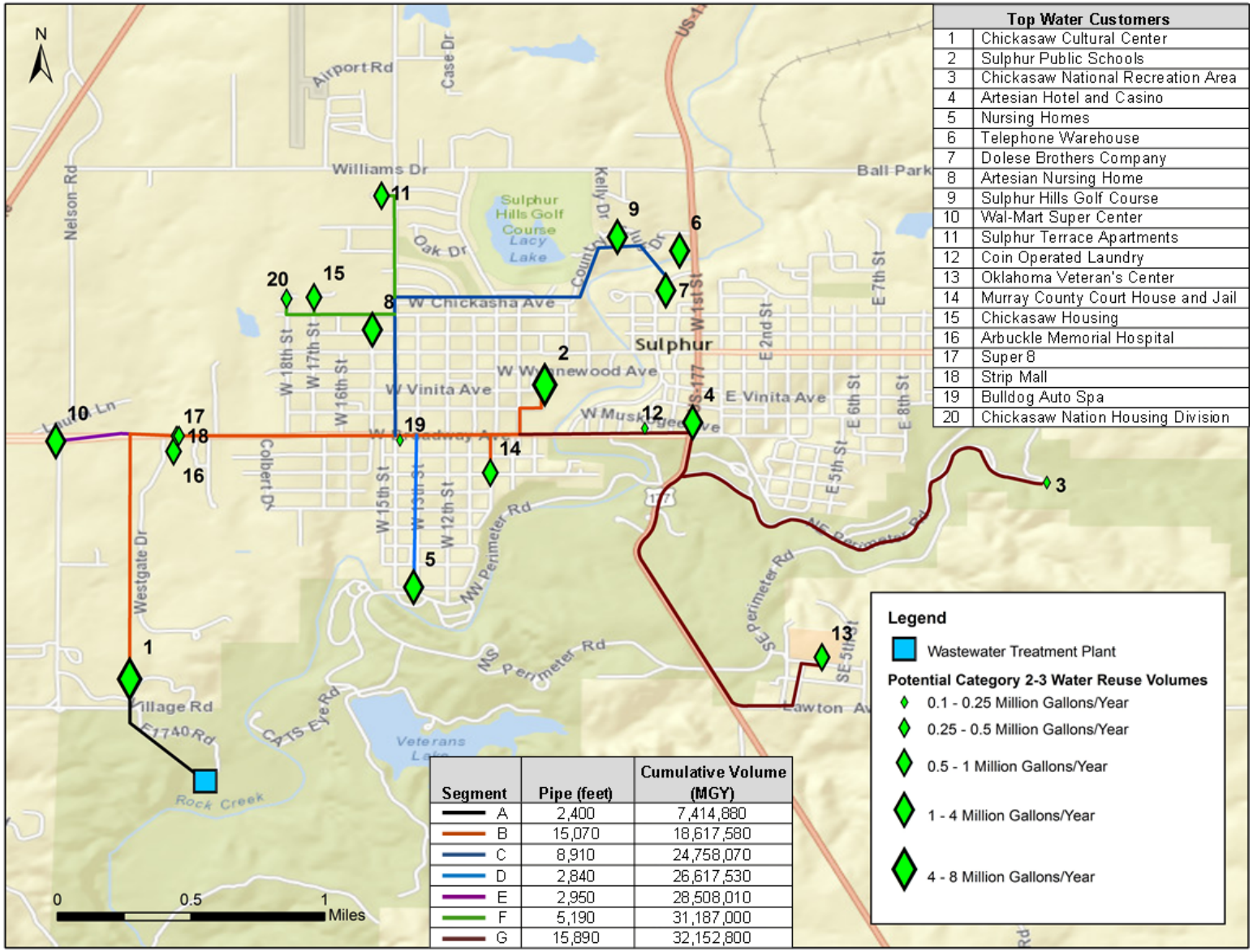

Figure 10. Proposed pipeline segments to distribution water to prioritized Category 2 customers, along with pipe required and expected reuse. Category 3 customers and uses are included.

To ensure appropriate sizing of infrastructure, daily and seasonal peaking factors were applied for the Category 2 as previously discussed. The peaking factors used were applied separately for irrigation, concrete activities (concrete mixing, dust control, and aggregate washing/sieving), and other Category 2 indoor uses (toilet flushing, heating/cooling, carwashes). The peak demands from each of these types of uses were assumed to occur at opposite times and cannot be added; instead a daytime peak demand (concrete and other) and nighttime peak demand (irrigation) were used in the hydraulic analysis.

- All the other uses are indoor uses and assumed to occur primarily over a 12-hour time period during business hours and a peaking factor of 2 (24/12) was applied.
- Seasonal peaking factors were also applied consistent with Category 3. All other uses are assumed to have no seasonal variations.

Table 17 provides a summary of the peaking factors and calculated peak uses. The daily total peak demand for potential Category 2 uses is 245,000 gpd since irrigation is the largest use, which is assumed to would occur opposite of concrete and other uses so these cannot be added. Infrastructure was sized based on the daily total peak demand and a decadal growth rate of eight percent through 2060, consistent with the population projections, to allow for future growth.

Table 17. Summary of irrigation, concrete (concrete mixing, dust control, and aggregate washing/sieving), and other demands and peaking factors assumptions.

Potential Category 2 Uses	Demand (MGY)	Demand (gpd)	Daily Peak Factor	Seasonal Peak Factor	Peak Demand (gpd)
Irrigation	14.23	39,000	2.4	2.6	245,000
Concrete	2.25	6,200	3	1.6	29,000
Other	15.68	43,000	2	-	86,000
2060 Irrigation	20.90	57,300	2.4	2.6	360,000

It was assumed that additional storage would not be needed to meet peak demands because the peak demand is less than half of the flow rate of wastewater treated at the WWTP. However, additional pumps would be required to meet the total peak demands and potential future growth. The pumps were sized based on a hydraulic analysis and costs were developed and included in estimates for Phase B through G. Table 18 provides a summary of the cumulative estimated costs of these phases. The estimated capital cost for these seven segments is approximately $2,152,000. Implementing Phase A-F was determined to be optimal due to the need to offset capital improvements at the WWTP, with the lowest cost per 1,000 gallons of $4.48. Phase A-F would provide 31.1 million gallons of recycled water each year, representing about 13.8% of the 226 million gallons treated at the WWTP annually.

It is important to point out again that the cost of retrofitting the plumbing systems at existing facilities to accommodate Category 2 indoor uses is not included in these cost estimates. It should be recognized that plumbing retrofits (i.e., installing a dual plumbing system) are site specific and may be cost prohibitive for existing facilities. In fact, the costs to retrofit existing facilities are estimated to be ten times the costs of constructing a new, dual-plumbed facility per foot of plumbing (San Francisco, 2012).

Table 18. Summary of the cumulative estimated costs of the three proposed Category 2 distribution system phases.[a]

Distribution Summary	**Proposed Category 2 Phases**						
Segment	A	A-B	A-C	A-D	A-E	A-F	A-G
Pipe (feet)	2,400	17,470	26,380	29,220	32,170	37,360	53,250
Volume (MGY)[b]	7,414,880	18,617,580	24,758,070	26,617,530	28,508,010	31,187,000	32,152,800
Total Capital Cost	$1,003,000	$1,355,000	$1,551,000	$1,614,000	$1,679,000	$1,793,000	$2,152,000
Present Worth of O&M Cost	$243,000	$593,000	$693,000	$725,000	$758,000	$816,000	$995,000
Total Capital and O&M Cost	**$1,246,000**	**$1,948,000**	**$2,244,000**	**$2,339,000**	**$2,437,000**	**$2,609,000**	**$3,147,000**
Annualized Capital Cost	$58,000	$78,400	$89,700	$93,300	$97,100	$103,700	$124,500
Annual O&M	$10,680	$26,130	$30,520	$31,920	$33,370	$35,930	$43,820
Total Annual Cost	**$68,680**	**$104,530**	**$120,220**	**$125,220**	**$130,470**	**$139,630**	**$168,320**
Total Annual Cost per 1,000 gallons	**$9.26**	**$5.61**	**$4.86**	**$4.70**	**$4.58**	**$4.48**	**$5.24**
Total Annual Cost per acre-feet	**$3,018**	**$1,830**	**$1,582**	**$1,533**	**$1,491**	**$1,459**	**$1,706**

[a] As previously described on page 42, these capital costs do not include the cost to retrofit existing facilities. Retrofitting costs would need to be determined by working with each of the potential Category 2 customers individually during a more detailed assessment.

[b] Volume includes Category 2 and 3 reuse.

SUMMARY AND CONCLUSIONS

The objective of this preliminary assessment, set forth within the context of recommendations included in Reclamation's Appraisal Investigation and Report titled "Sulphur Pipeline Regional Rural Water Supply Project", was to determine whether development of a direct, non-potable reuse water supply alternative for Sulphur could reduce long-term pumping from the Arbuckle-Simpson Aquifer and provide at least 295 acre-feet per year of water by 2060 to meet Sulphur's future projected demands. The preliminary market assessment for this investigation showed that non-potable water reuse use potential currently totals between 49 and 109 acre-feet per year for Category 3 and 2 uses, respectively. For 2060, these uses may increase to between 71 and 160 acre-feet per year.

Although these volumes fall short of the full amount potentially needed to offset Sulphur's projected water supply deficit, benefits of implementing a water reuse project certainly exist, for every acre-foot of water recycled is an acre-foot of potable water offset, which thereby either offsets or postpones an acre-foot of water either pumped out of the Arbuckle-Simpson Aquifer or conveyed from Lake of the Arbuckles (the latter assuming a pipeline is built).

The approach employed in this assessment provides a range of costs associated with implementing a reuse project that services the top water users in Sulphur both with and without WWTP improvements, beginning with the closest customers that provide the largest benefit per unit cost. For example, providing Category 3 recycled water to the nearby Chickasaw Cultural Center yields the greatest unit cost benefit (3.4 million gallons at a cost of about $84,000). These costs are preliminary and based on existing data, and are thus contingent upon numerous factors such final design and actual site conditions. Next steps would include confirmation that the WWTP effluent meets Category 3 regulatory standards associated with turbidity, nutrients and fecal coliform, and chlorine disinfection, as well as direct coordination with potential reuse customers to confirm willingness to participate.

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APPENDIX A: SULPHUR WWTP DRAWINGS

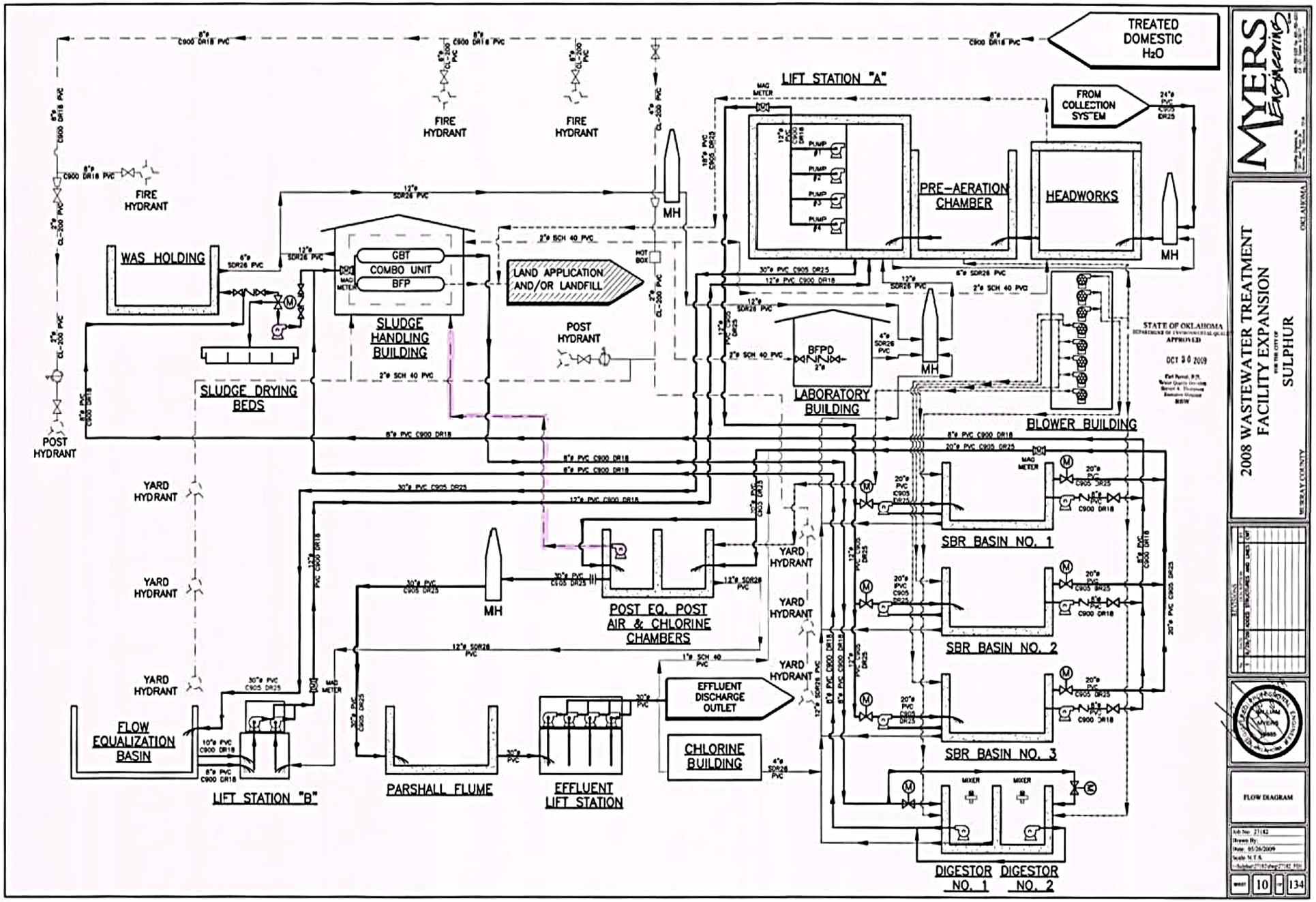

Figure A.1 Sulphur WWTP process flow diagram.

APPENDIX B: BASIS OF COST ESTIMATES

Purpose and Intended Use of the Cost Estimates

The cost estimates are considered "preliminary-level", as defined by Reclamation's Directives and Standards FAC 09-01, which states: "preliminary cost estimates developed and produced to document a very preliminary analysis performed to look at a given problem, need, or opportunity utilizing readily available data. The estimates do not meet the criteria used for preparation of either Appraisal or Feasibility cost estimates." Table B.1 below identifies the project development timeline and level of cost estimates produced.

Table B.1 Types of cost estimates produced for each project planning stage (D&S FAC 09-01).

PROJECT STATUS	PROJECT STAGE	LEVEL OF COST ESTIMATE PRODUCED
Planning	Planning	***Preliminary***
		Appraisal
		Feasibility
Construction	Design	Percent Design [Updated feasibility]
		Prevalidation of Funds
	Solicitation	Independent Government Cost Estimate [Award]
	Construction	Independent Government Cost Estimate for Contract Modifications
Operation and Maintenance	Operations	One or more of the previously identified estimates

Basis of Cost Estimate

The cost estimates were prepared by Reclamation staff and are in 2014 dollars. Details are provided in Appendix D. The unit costs were derived for each quantity using the construction cost data that has been compiled in the RSMeans Heavy Construction Cost Data and market values provided by various distributors near the District. A location factor was used to adjust only the unit cost data provide by RSMeans Heavy Construction Cost Data (Reed Construction, 2012) to Admore, Oklahoma, which is 79.6% of the national average. The cost estimates are divided into the following key elements:

- Contract Costs: estimated cost of the contract at the time of bid or award.
  - Mobilization: A value of 5 +/- % was utilized for mobilization. This includes costs of contractor bonds, and mobilizing contractor personnel and equipment to the project site during initial project start-up. The assumed 5 +/- % value in the cost estimate is based upon past experience of similar projects.
  - Design Contingency: For packaged systems a value of 20 +/- % was used for (i) unlisted items, (ii) design and scope changes; and (iii) cost estimating refinements.
- Construction Contingency: A value of 25 +/- % was used for construction contingencies based upon the completeness and reliability of: the engineering design data, geological information, projected quantities, and the general knowledge of the conditions at the site.

It covers minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties.

- Non-Contract Costs: A value of 15 % was used for noncontract costs such as soil surveys, water quality testing, environmental compliance, engineering designs, and construction management.

Annual operations and maintenance (O&M) costs were calculated for the pipeline, pumping plant, and WWTP improvements. Power costs for pumping plants were also calculated. An assumption of $2,600 per mile of pipe per year was used to calculate the O&M costs for the pipeline. The pumping plant and WWTP improvements' O&M costs were assumed to be one percent of the capital costs of each. The power costs for the pumping plants were calculated based on an assumed electric cost of $0.0511 per kilowatt required.

Annualized capital costs were calculated based on a planning period of 30 years and an interest rate of 1.9 %. This interest rate was selected from the real interest rates on Treasury Notes and Bonds for a 30-year duration (Office of Management and Budget, 2013). All alternatives and components were assumed to have a useful life of 30 years and no salvage value was include for the items.

APPENDIX C: PRELIMINARY COST ESTIMATES

APPENDIX D: WWTP PACKAGED SYSTEM QUOTE