PHASE 1 WASTEWATER FEASIBILITY STUDY
City of Tuttle, OK

Prepared for:

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C. H. Guernsey & Company
5555 N. Grand Blvd.
Oklahoma City, OK 73112
405.416.8100

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 BACKGROUND

The City of Tuttle (City), Oklahoma is located southwest of Oklahoma City in Grady County. Other nearby communities include Mustang (north), Minco (west), Newcastle (east), and Bridge Creek (south).

The City is experiencing rapid growth, primarily in the northeast portion of the community along State Highway (SH) 4, south of the Canadian River. This growth is primarily due to the 2001 construction of SH 4 and the new bridge over the Canadian River, which ultimately connected Tuttle to the City of Mustang and southwest Oklahoma City, making the community much more accessible. The intersection of SH 4 and SH 37 is a focal point for future growth and increased commercial activity.

This rapid growth has created a need for the City to review its infrastructure, both water and wastewater. The water system has recently been updated by the addition of new distribution service to areas previously using wells. Additionally, a new water plant was recently constructed to address the growing population and community needs.

The City's wastewater system requires further evaluation to meet the needs of the existing and future growth. The City currently supports and maintains a multi-lagoon wastewater treatment system located just north of downtown Tuttle. The system is nearing its capacity to treat existing flows, and is not capable of adding new flows that would be created by providing sewer service to the growth areas to the east. There is a need to evaluate the development of a comprehensive sewage collection and wastewater treatment system for the community. This study has been commissioned by the City and designed to analyze the feasibility of a new and expanded wastewater system.

1.2 GOAL AND OBJECTIVES

Goals and objectives (G&Os) are provided to guide the planning effort and will ultimately serve as benchmarks for measurement of success of the project. The G&Os for this study are described below:

- Determine/estimate when and where future growth will occur.
- Estimate future residential, commercial and industrial sewage flows.
- Provide a comprehensive sewer collection plan that provides service to most if not all the developed or likely developable land area in Tuttle.
- Minimize lift stations to the maximum extent possible.
- Replace the existing lagoon system if feasible and cost effective.

- Provide a wastewater treatment concept that is expandable and suitable for existing and foreseeable future discharge requirements.
- Site the wastewater treatment plant out of the floodplain.
- Help create a consensus as to the growth vision of Tuttle management and citizenry.
- Use the study and follow-on implementation as a catalyst for growth.
- Use the study and follow-on implementation as a source of civic pride for the Tuttle residents.
- Determine if there is opportunity for collaboration between Bridge Creek and the City of Tuttle.
- Develop a utility management control methodology that guides connection to the system.
- Provide a plan for phased development of the system that can be supported by the fiscal resources available to Tuttle.
- Create an environment to make this an enjoyable and professionally rewarding project for all participants.

1.3 ACKNOWLEDGEMENTS

This study required contributions from key individuals with the City of Tuttle. Personnel that we would like to acknowledge for their efforts, input, and knowledge include:

- Bobby Williams, Mayor
- Tim Young, City Manager
- Jay Brunson, Council Member
- Alan Douglas, Council Member
- Taylor Henderson, Council Member
- Brian Routh, Council Member
- Jeff Cowan, City Engineer
- Don Cluck, Police Chief & previous interim City Manager
- Gary Shockley, Interim Public Works Director

1.4 STUDY FORMAT AND LAYOUT

The layout for this report is presented in the Table of Contents and is self-explanatory. Report sections are clearly identified and are divided into enough detail so that the reader can properly identify/determine the information being presented.

2 PROJECT SCOPE

Subsequent to selection for contract award, a detailed scope of services was prepared to address project requirements. This scope of services was discussed with and ultimately approved by the City. The scope for this project is presented below.

Task 1: Address Project Planning and Coordination Activities – Upon receipt of the notice-to-proceed, GUERNSEY began coordination with the City to obtain preliminary data, arrange for a kick-off meeting, and have an internal project meeting with staff to outline project needs and requirements.

Task 2: Participate in Kick-off Meeting and Perform a Site Reconnaissance of the Study Area – GUERNSEY participated in a meeting to kick-off the project with City staff. The intent was to introduce key team members, review scope, and budget, address schedule, and gather other important data/information required for the study. Additionally, GUERNSEY discussed the City's views on options and alternatives being considered.

GUERNSEY performed a windshield reconnaissance/site visit of the City corporate limits to observe a variety of conditions including the following:

- Existing WWTP and associated facilities/systems
- Existing land use, zoning, and growth patterns
- Existing topography, hydrology, and geology
- Identify opportunities for new growth and potential location of the proposed new WWTP
- Take photos of the Tuttle community and appropriate facilities

Task 3: Meet with the Oklahoma Department of Environmental Quality (ODEQ) – Very early in the process, a meeting with ODEQ was conducted to express the potential plans of the City and to begin discussing the permit conditions that will be required. These discussions will ultimately help determine treatment requirements and the alternative treatment options that can be considered.

Task 4: Review the Status of the Wasteload Allocation Study (WLAS) with the Association of Central Oklahoma Governments (ACOG) – GUERNSEY and the City are in communication with ACOG to review the status of the WLAS and how the study might affect Tuttle.

Task 5: Prepare a 30-year Population and Industry Growth Projection – GUERNSEY has prepared a 30-year projection of population growth and industrial development. These projections are utilized to estimate domestic and industrial sewage contribution and estimate the customer base for debt service and rate calculations. GUERNSEY began with the Oklahoma Department of Commerce (ODC) cohort survival model which currently predicts the population of Oklahoma communities to the year 2030. In communication with the City council and staff, GUERNSEY adjusted the projections based on recent trends, industrial development activity, and the growth desires of the citizens of Tuttle. The deliverable is a projection of population in five-year increments over the probable 30-year financing period for the new plant and system.

Task 6: Identify and Evaluate Treatment Alternatives – There are several fundamental sewage treatment technologies available, each of which has a myriad of variations in terms of the treatment provided and the required equipment. To evaluate suitable treatment strategies for the new plant, various factors must be considered and addressed. These factors include, but are not limited to:

- The expected discharge consent to be imposed on the new plant
- The expected volume, nature, and concentration of sewage to be treated
- The expected amount and type of sludge produced using a given treatment type, and the method of sludge disposal (landfill, land application)
- The production of odors and the requirement for odor abatement
- ODEQ requirements for WWTPs
- Whether a treatment process can operate under gravity or if pumping is required
- The expected operational costs (power, chemicals, consumables, labor, sludge disposal, etc.)
- The expected capital costs

GUERNSEY prepared a basis of design that states the parameters (flows, volumes, concentration, composition, etc.) on which the evaluation is based. The parameters were obtained from the existing City treatment system where possible, or by using recognized engineering design guides if data is unavailable. Subsequent to the completion of the basis of design, a matrix has been developed that evaluates various treatment technologies in terms of the factors mentioned above and a scoring system will be assigned to rank the technologies.

Task 7: Perform Site Selection Evaluation for the New Plant – There are many factors to consider regarding site selection for the new plant including, but not limited to:

- Being downstream from the City
- Point of discharge (into Canadian River directly, not into a tributary)
- Topography/slopes (layout of sewer network to minimize pumping)
- Traffic movements (access and egress to main roads, volume, type)
- Local wind conditions (movement of potential odors)
- Availability of nearby services (electricity, gas, water, telephone)
- Land availability
- Land use compatibility
- Security and isolation of the facility
- Visual impact
- Floodplains
- Environmental issues (Section 404 permit, threatened and endangered species, cultural resources, wetlands, hazardous waste sites, etc.)
- Not in my backyard (NIMBY)/public perception

GUERNSEY prepared a constraints and opportunities map for the most desirable parts of the City that recognizes and addresses the abovementioned issues. This resulted in identification of areas within Tuttle that would be acceptable for the treatment plant location. The higher priority areas will be on the downstream side of the community near the Canadian River, to facilitate direct discharge to the river.

Subsequent to completion of this map, a matrix was developed that evaluates the various sites that meet the criteria and a scoring system was assigned to determine the best site.

Task 8: Prepare Preliminary Conceptual Layout of Proposed New System – From the treatment matrix developed during Task 6 and the site matrix developed during Task 7, GUERNSEY proposed a site and treatment technology combination that best meets the City's requirements and minimizes adverse impacts. GUERNSEY prepared preliminary conceptual layout drawings that show the proposed new plant, access/egress routes, utility connections, sanitary sewer network, effluent discharge route, and outfall location. From the concept drawings, GUERNSEY developed high-level cost estimates for the installation of the proposed system.

Task 9: Develop a Phased Estimate of Probable Costs – Based on the selected treatment option and sewer system layout, GUERNSEY performed "take-offs" of line lengths, manholes, creek crossings, lift stations, etc. and estimated construction costs, easement costs and soft costs for engineering and financing. Since development will occur over time, the improvements were phased in five-year increments. The estimate includes contingencies, escalation for projects constructed in the future, and interest rates. Finally, a budget for operations of the system and treatment facility was provided for use in the rate analysis.

Task 10: Preliminary Rate Analysis – From the high-level cost estimate, GUERNSEY performed a preliminary, high-level rate analysis to determine the likely order of magnitude of future sewer charges.

Task 11: Prepare Draft Feasibility Study Report – GUERNSEY completed a draft report for this project. The report includes the following:

1.0 Introduction
2.0 Project Scope
3.0 Study Methodology
4.0 Existing General Community Conditions
  4.1 Location and Climate
  4.2 City Government
  4.3 Land Use/Zoning
  4.4 Existing Wastewater Infrastructure and Regulatory Issues
  4.5 Demographics/Past, Current, and Projected Growth
5.0 Evaluation of Treatment Plant Alternatives
  5.1 Treatment Types for Consideration
  5.2 Evaluation of Alternatives
6.0 Plant Location/Site Selection
  6.1 Siting Criteria
  6.2 Constraints and Opportunities
  6.3 Site Evaluations
  6.4 Conclusions/Recommendations
7.0 Conceptual Plan
8.0 Preliminary Rate Analysis
9.0 Summary
10.0 Conclusions/Recommendations

Task 12: Present Study Findings to the City Council – GUERNSEY will make a PowerPoint presentation to the City Council regarding the results of the study and document any comments at that time. The City will then review the draft report in detail and provide consolidated written comments to GUERNSEY.

Task 13: Address Comments and Prepare Final Feasibility Study Report – GUERNSEY will address comments from the City and prepare a final report. It should be noted that GUERNSEY will meet frequently with City officials throughout the process. Activities requiring decisions will be addressed as needed before moving forward. The City will be consulted at all times.

3 STUDY METHODOLOGY

The project involved several key meetings throughout its duration. Important meetings and communication sessions were addressed on the following dates:

- February 4, 2009: Kick-off Meeting.
- April 17, 2009: Meeting with Oklahoma Department of Environmental Quality (ODEQ).
- July 20, 2009: City Council Presentation.

Summaries of the meetings are presented in Appendix A.

Additionally, throughout the duration of the project, various reconnaissance activities were undertaken to observe conditions throughout Tuttle related the development and siting of the wastewater collection and treatment system.

4 EXISTING GENERAL COMMUNITY CONDITIONS

4.1 INTRODUCTION

A location plan for the City is shown in Figure 4-1 and a map of the City is shown in Figure 4-2.

The City of Tuttle is located on the south bank of the Canadian River in the northeast corner of Grady County in central Oklahoma. The western edge of the City of Oklahoma City is situated on the opposite bank of the Canadian River, and downtown Oklahoma City is located approximately 20 miles northeast of the City. The City is located on SH 37, which runs east-west through the City. The highway connects the City to Interstate 44 (I-44), located approximately 9 miles east of the City. SH 4 traverses north-south through the City; this connects I-40 (located approximately 12 miles north of the City) to I-44 (located approximately 5 miles south of the City). The original part of the City ('Old Tuttle') is located on SH 37 in the southwest corner of the City. Due to the construction of a new bridge in 2001 that extended SH 4 south to I-44, growth has concentrated in the area of the intersection of the two state highways ('New Tuttle').

The City is largely an agricultural community with a focus on wheat, cotton, hay and cattle. Located immediately west of the City is the Braum's Dairy Farm, which is the largest farm in the area. The City also acts as a minor commuter community to Oklahoma City. The City encompasses an area of 29.2 square miles, and the population was 4,294 at the 2000 United States Census[1]. According to City records, the population reached 6,000 in July 2009.

4.2 CLIMATE AND TOPOGRAPHY

Grady County is located in the Central Great Plains and the climate is classified as continental, temperate and sub-humid with an average annual temperature (1971-2000) of 61.6°F and an annual average precipitation of 35.28 inches[2]. A topographic map of the City is shown in Figure 4-3.

The City overlooks the Canadian River on gently undulating land that slopes northward toward the river. The southern edge of the City is located at an elevation of approximately 1,300 ft and slopes gently north to an elevation of approximately 1,250 ft and ends abruptly to form a line of 50 ft high bluffs that mark the edge of the floodplain. Due to meandering of the river, the toe of the central section of bluffs is "tight up against" the river bank and there is no floodplain; however, at the western and eastern bluff sections, the river is some distance away from the bluffs and there is wide, flat land between the toe of the bluffs and the river bank.

The undulation of the land is due to valleys created by creeks flowing north into the Canadian River. The City is drained by five main creeks: West Creek, East Creek, Worley Creek, Indian Creek and Coal Creek, plus two unnamed creeks. The central bluffs section is located between Worley Creek and Coal Creek. The original part of the City is located between West Creek and East Creek.

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[1] http://en.wikipedia.org/wiki/Tuttle,_Oklahoma

[2]http://climate.mesonet.org/county_climate/Products/County_Climatologies/county_climate-grady.pdf

Figure 4-1: City of Tuttle – Location Plan

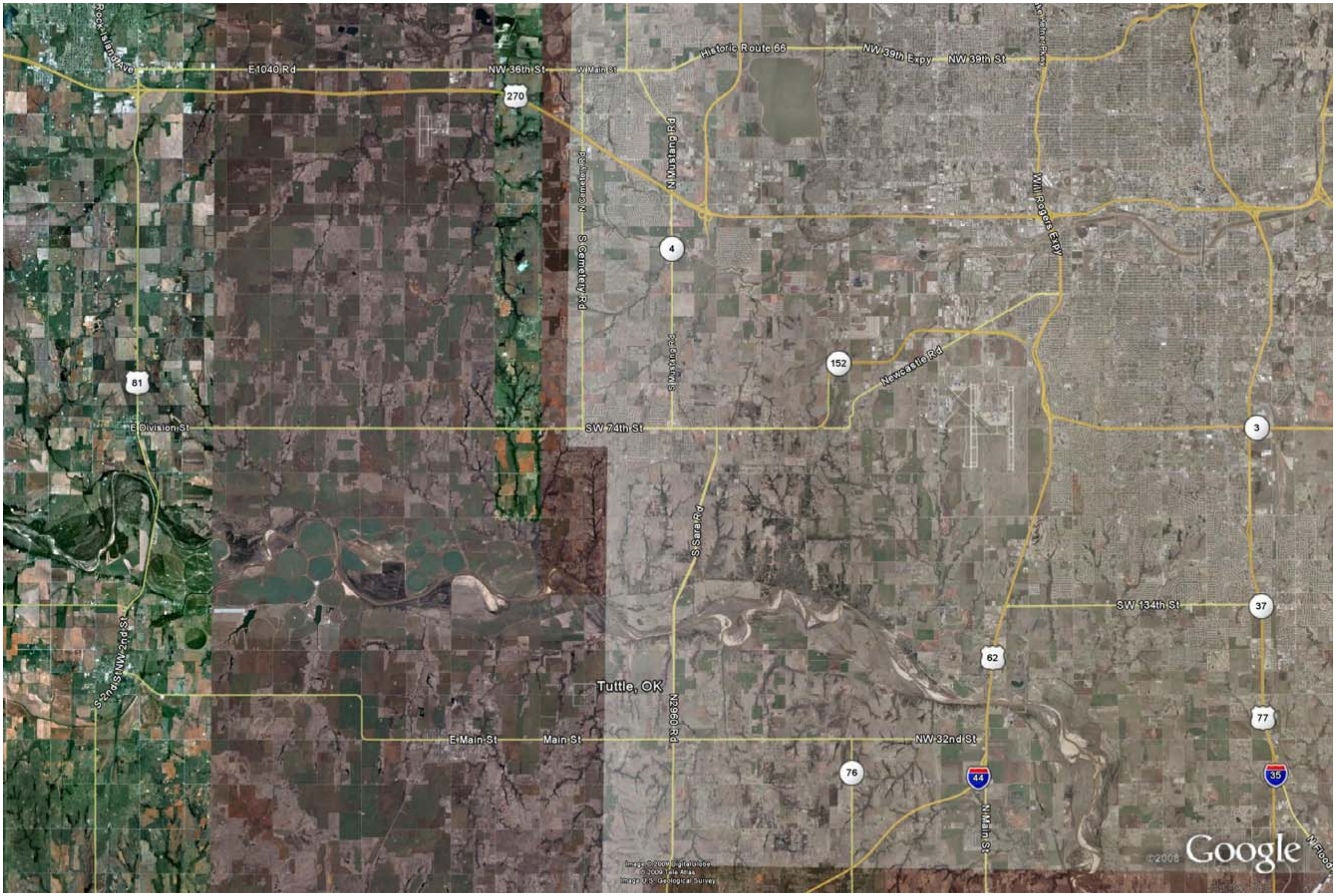

Figure 4-2: City of Tuttle - Map

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Figure 4-3: City of Tuttle – Topography

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4.3 GEOLOGY

The City is located in the Red Bed Plains Sub-region, of the Osage Plains Section, of the Central Lowland Province, of the Interior Plains Physiographic Region of the United States[3]. Geologically, the City is located on the southeastern portion of the Anadarko Basin[4]. The City is underlain by the Duncan Formation (Permian), which consists of sandstone containing mudstone and siltstone conglomerates, to a depth of approximately 300 ft. This is underlain by the Hennessey Formation (Permian), which consists of silty mudstone, muddy siltstone and minor, very fine grained sandstone, to a depth of approximately 650 ft. Alluvium (consisting of clay, silt, sand and gravel) is found in the bottom of the creek valleys to depths of 25 ft. The Canadian River floodplain is covered in alluvium to depths of 50 ft. Adjacent to the floodplain there are also some remnants of older river terrace deposits, located some 40 to 90 ft above the modern floodplain[5].

4.4 LAND USE/ZONING

In 2005 the City produced *Tuttle* 2020, a comprehensive master plan detailing the development of the City. The plan included the then current land use (Figure 4-4) and the planned future use of land (Figure 4-5) as the City develops. Currently, the City is predominantly agricultural in nature, with 81% of the land being cultivated in 2005. Outside of Old Tuttle, residential development is occurring close to SH 37 and east of SH 4. Commercial development is also occurring along SH 37 on either side of SH 4. Scattered throughout the City are small pockets of industrial development.

The 2020 master plan calls for the City to develop east of Cemetery Road, with the land use west of this road to remain the same (i.e. largely undeveloped agricultural land). Commercial development is targeted to occur along SH 4 and to continue along SH 37 in two sections; and the intersection and east of SH 4, and the intersection with Cemetery Road. Future residential development is shown as occurring from Cemetery Road and extending all the way to the eastern corporate boundary to infill the land on either side of the commercial development. This area of residential and commercial development is approximately 13 square miles, or 45% of the City's area. The plan does not call for any increase in industrial development anywhere within the City.

Persons familiar with the 2005 study indicate that the driver for the plan was a desire to maintain a "rural feel" to the city.

Most of the land north of Silver City Ridge Road is located within the Canadian River floodplain. In addition, floodplains exist along the creeks that flow north into the Canadian River. The extent of floodplains within the City's corporate boundary is shown in Figure 4-6.

Land within the floodplain is likely to remain free from residential and commercial development due to the flooding risk. The total amount of land within the City's corporate boundary that is outside of the floodplain is approximately 22.5 square miles.

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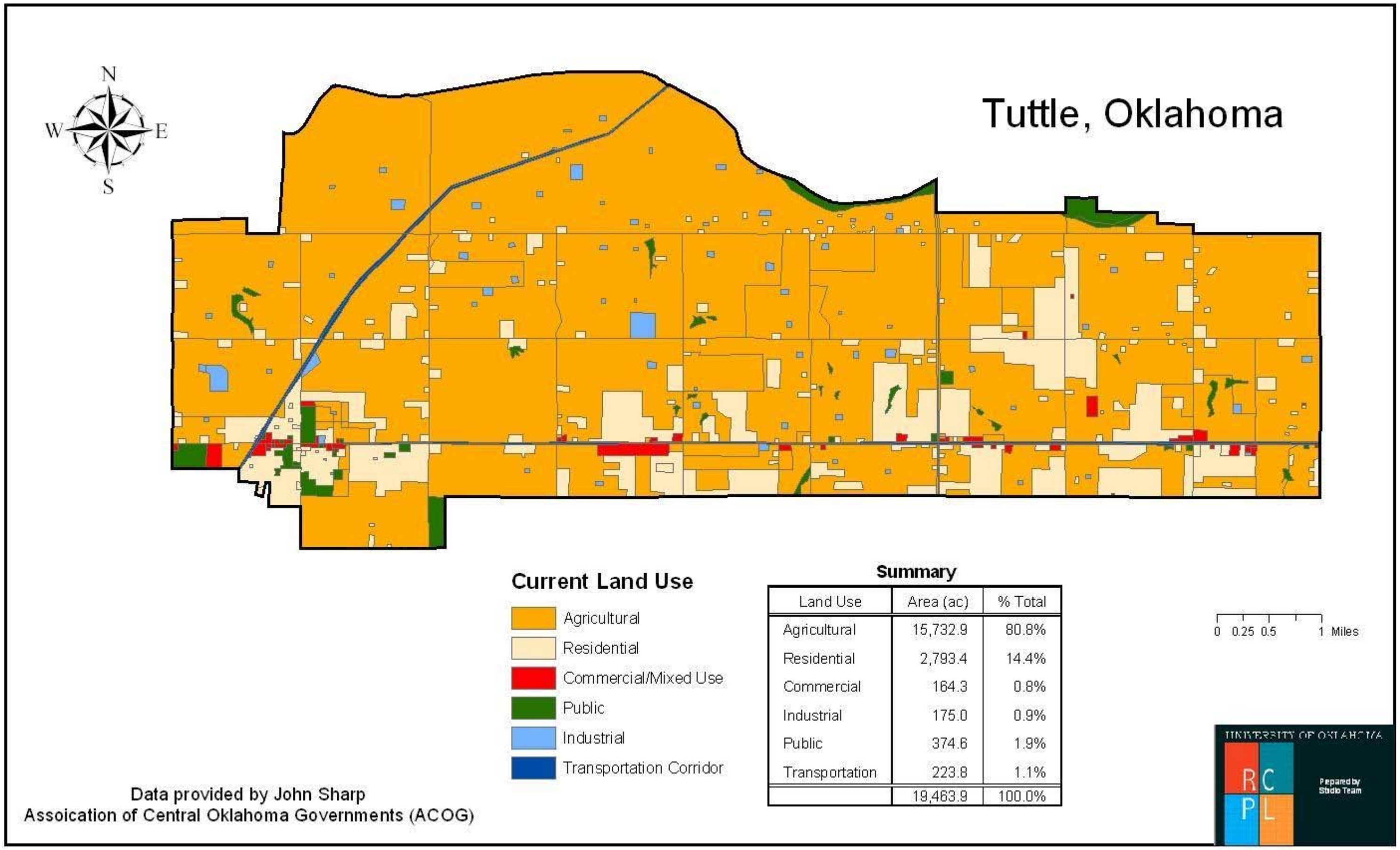
[3] http://tapestry.usgs.gov/physiogr/physio.html

[4] http://www.okgeosurvey1.gov/level2/geology/ok.geo.provinces.large.gif

[5] http://www.ogs.ou.edu/StatemapOGQ/OGQ-23_Oklahoma_City_SW_24K.pdf

Figure 4-4: City of Tuttle – Current Land Use
(From *Tuttle 2020* Comprehensive Plan)



Summary

Land Use	Area (ac)	% Total
Agricultural	15,732.9	80.8%
Residential	2,793.4	14.4%
Commercial	164.3	0.8%
Industrial	175.0	0.9%
Public	374.6	1.9%
Transportation	223.8	1.1%
	19,463.9	100.0%

Figure 4-5: City of Tuttle – Future Land Use
(From *Tuttle 2020* Comprehensive Plan)

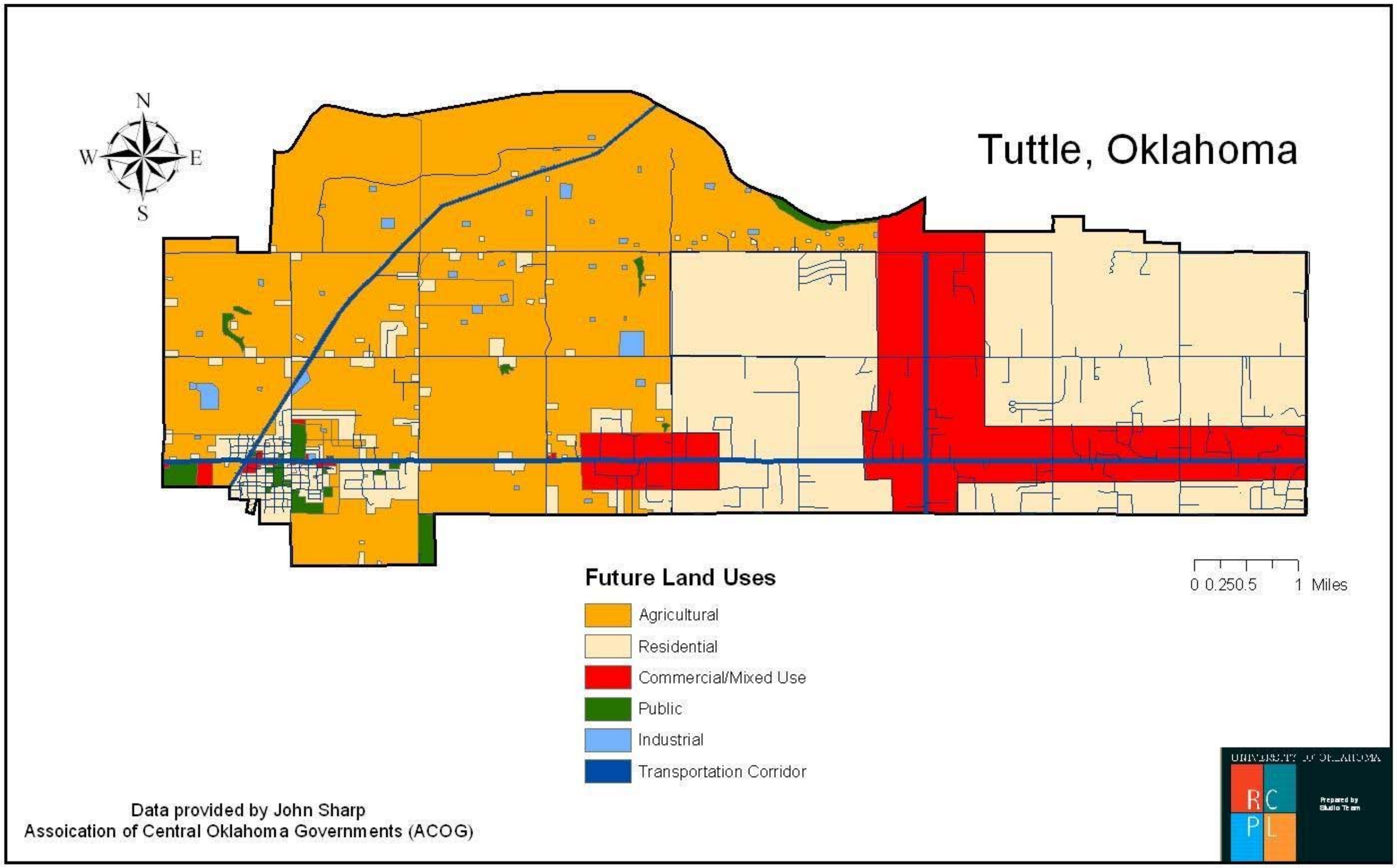


Figure 4-6: City of Tuttle – Floodplain

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4.5 EXISTING WASTEWATER INFRASTRUCTURE AND REGULATORY ISSUES

There is a distinction within the City of Tuttle as to the nature of the wastewater infrastructure between Old and New Tuttle.

The City owns and operates a publically owned treatment plant (POTW) that is located on the northwest edge of Old Tuttle (Figure 4-3). The POTW treats effluent from Old Tuttle and serves approximately 900 people. The plant consists of six flow-through lagoons; four primary lagoons and two secondary lagoons. The plant originally had two lagoons and was extended to six lagoons in 1986.

Sewage flows to the POTW under gravity and discharges into the two middle primary lagoons (#1 and #2). From these two lagoons, flows are discharged under gravity into two downhill primary lagoons (#3 and #4), which in turn discharge into a lift station. The flows are then pumped to two secondary lagoons (#5 and #6) located uphill of the two middle lagoons. The lift station discharges into lagoon #5, which then discharges under gravity into lagoon #6. Final effluent from lagoon #6 is discharged under gravity into a swale that runs downhill around the edge of the lagoons. The ditch discharges into a small stream that heads northwest for approximately 1,000 ft before discharging into West Creek.

The POTW is currently operating at 50-60% of its design capacity, and is capable of handling additional flows within the area served by the existing sewerage system. City staff has reported that ODEQ have no regulatory issues with the plant.

Outside of Old Tuttle, residential development, to date, has consisted of large lots that utilize on-site sewage treatment systems, such as septic tanks. City staff has not heard of nor had reported to them any concerns regarding the use of such systems. However the City is concerned about a potential long-term threat to the City's water supply (which is obtained from groundwater wells) from septic tanks due to leaks, overflows or inadequate treatment.

5 GROWTH AND SEWER FLOW PROJECTIONS

5.1 DEMOGRAPHIC & PROJECTED GROWTH

A logical step in predicting the future is an analysis of the history of the City and the historical trends in population growth. The following sections evaluate the demographics of the City (and Grady County and Oklahoma) and forecast the growth in the service area to the year 2060 using various methodologies. This growth projection data will form the basis for a phasing plan for the development of a wastewater collection and treatment system.

5.1.1 POPULATION PHILOSOPHY

Population projections are required to estimate future wastewater flow rates; determine and size the collection system; design treatment improvements; estimate capital costs; and determine financing scenarios. A "conservative low" projection results in inadequate future service and constrains growth. Conversely, an "aggressive high" projection creates excessive indebtedness in that the debt service expense is allocated to the base of taxpayers and ratepayers that exist during a 30-year financing period. If no significant additional growth occurs, these citizens pay excessive rates for a partially used resource.

The ideal population projection reflects the practical and historical realities of the State, County, and City. In addition, the projection encompasses the philosophy of growth held by the City's management and constituents. Stated another way, many communities are satisfied with their current size and consciously limit expansion. Other communities are aggressively seeking new development and are investing in both short- and long-term growth. The remaining cities and towns fall somewhere in between. The population projection must represent the probable long-term (50-Year) development culture and growth dynamic of Tuttle.

Wastewater systems are, however, flexible in terms of phasing. Not all of the improvements are required immediately and phased expansion can occur when population "triggers" justify the infrastructure investment. That means that a projected future population may occur on the date predicted or five years earlier or later. Whenever the customer base justifies the investment, the city can pull the "trigger" on the project. What is key in this master plan is that the ultimate "build out" is projected so that no downstream bottlenecks impact the system. The collection and treatment system must be designed to accommodate the wastewater contribution anticipated in 2060.

5.1.2 SERVICE AREA

The population projections must predict the boundaries of the proposed service area. Historically, communities in Oklahoma have chosen to operate and maintain their infrastructures independently. There are a variety of reasons for this independence, ranging from a desire to maintain control of revenues, to the civic pride inherent in the self-sufficient capabilities of the community, to the desire not to be "held hostage" by another city, and in some cases jealousy/rivalry amongst communities. Although far from becoming the norm, there appears to be increasing interest in regionalization of utilities. The reasons are compelling and relatively straightforward. Many municipalities, particularly the smaller communities, do not have the resources necessary to fully comply with regulatory requirements or the current levels of good engineering practice. Similarly, collaboration among communities provides some "economy-of-scale" benefits and a lower unit cost of the services. Finally, pooling of management, technical services, operations, and maintenance resources invariably results in a higher level of service and an optimum level of Operation & Maintenance (O&M) expense. For the purposes of this study, the service area will include the City limits and reasonable drainage basins south of the City proper. Predominately this includes parts of the unincorporated Bridge Creek population.

5.1.3 LONGEVITY OF CAPITAL IMPROVEMENTS

The Oklahoma Department of Commerce (ODC) projections, prepared by the Bureau of Census, address a duration of 25-30 years. For capital planning purposes, 20 years is reasonable for the life span of major equipment at a plant or supporting lift stations, 40-50 years for structures, and 50-100 years for collection lines and sewers.

5.1.4 STATE DEMOGRAPHICS

A number of statistically valid models have been developed for projecting population growth. Essentially the models use census data, mortality and birth rates, migration analysis, age demographics, trend analysis, and other data to formulate projections. The "official" projections used in this report were prepared by the ODC using methods and data provided by the US Census Bureau. This methodology is termed a "Five-Year, Cohort Survival, Regression Model" and essentially predicts that the level of economic development will remain constant and that growth will be influenced by migration and changes in demographics. Some of the statewide trends and characteristics of Oklahoma, Grady County, and Tuttle are described below:

- In the year 2000, Oklahoma was ranked the 27th most populous state in the nation (3,372,514 people). In 2002, Oklahoma was ranked 28th with a population of 3,493,700.
- By the year 2025, Oklahoma is projected to increase in population to 4,056,536. This 16.1% increase ranks as the 23rd highest rate of increase in the nation.
- Of this 562,836-person projected increase, approximately 65,000 will enter Oklahoma as a result of international migration and approximately 290,000 people will enter Oklahoma as a result of internal (US) migration (13th highest in the US).
- The remaining 202,000-person increase will result from natural increases (birth minus death).
- The age demographics in Oklahoma and the rest of the nation will change dramatically by the year 2025. The proportion of Oklahoma's population classified as elderly is expected to increase from 13.5% to 21.9% in 2025.
- Oklahoma's dependency ratio, the number of youth under age 20 and elderly age 65 and over, versus people of working age (age 20 to 64) is expected to rise from 76.1% to 89.5% by the year 2025.

The significance of this "graying" of Oklahoma scenario is that the debt service for municipal projects will be increasingly paid by people on retirement or reduced/fixed incomes.

5.1.5 OKLAHOMA, GRADY COUNTY AND TUTTLE DEMOGRAPHICS

Regional and local relevant statistics include:

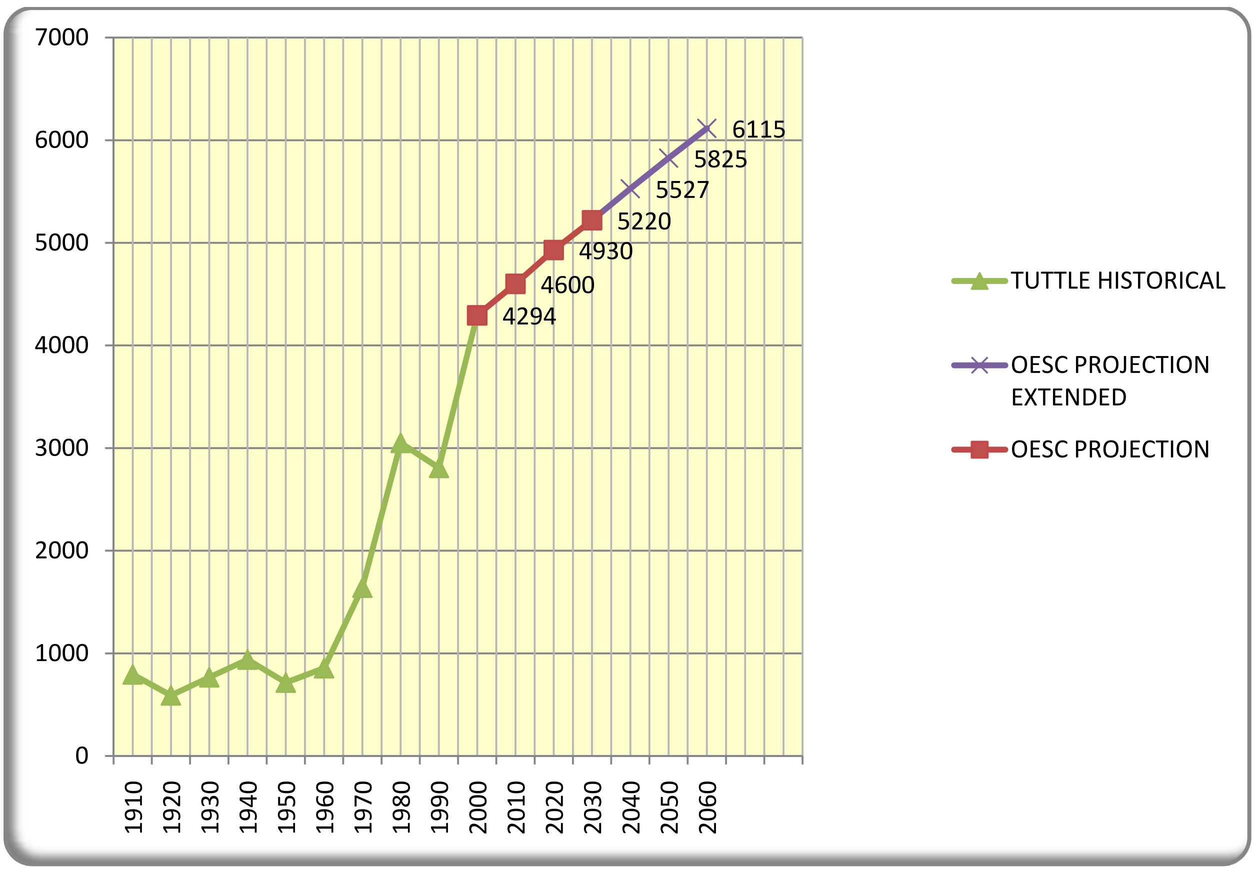
- From 1990 to the year 2000 the population of Grady County increased an average of 377 people per year, equating to a 9% overall growth rate for the decade. The 2000 population was 45,516. The county population in 2007 was estimated to be 50,615.
- There were 17,341 households in the county in 2000, with an average occupancy of 2.62 people. There were 12,797 families.
- The median Grady County household income is $32,625, based on the 2000 census. Per capita income was $15,846. About 19.9% of the population was below the poverty level.
- In Grady County, 66% of the population is rural, and 34% is urban. Population density was 41 people per square mile.
- The cost of living index in Grady County is a low, 78.8, compared to the US average of 100.
- In 2000 the county racial makeup was 87.31% White, 3.06% Black, 4.85% Native American, 2.89% Latino, 0.34% Asian, 0.04 Pacific Islander, 1.12% from other races and 3.28% from two or more races.
- The median county age was 36 with 13.1% over the age of 65. For every 100 females age 18 and over, there were 91.3 males.
- The City of Tuttle had a 2000 population of 4,294.
- From 1990 to 2000, the City gained 1,487 residents.
- In 2000 Tuttle had 1,585 households, with an average size of 2.71 occupants. There were 1,272 families.
- The median income for a household was $40,396. Of the households in Tuttle, 5.8% of families were below the poverty level ($17,603 for a family of four).
- The median age of Tuttle residents was 37 years with 10.7% over the age of 65.
- The 2008 cost of living index is 79, compared to 100 for the US, and 91.3 for Oklahoma City.
- For every 100 females over the age of 18 there are 92.4 males.
- In 2000 Tuttle's racial makeup was 91.34% White, 4.98% Native American, 2.21% Latino, 0.16% Asian, 0.09% from other races and 3.42% from two or more races.

In 2008 a demographic estimate was made by the Oklahoma Cooperative Extension Service, Oklahoma State Center for Rural Health. A comparison of Tuttle and the State of Oklahoma is shown in Table 5-1.

Table 5-1: 2008 Estimated Demographics

PARAMETER	TUTTLE	OKLAHOMA
Females	50.6%	50.6%
Median resident age	37.2	35.5
Median household income	$53,335	$41,567
Median house value	$137,256	$103,000
White	90.0%	78.3%
Foreign born	0.7%	3.2%
Average household size	2.7	2.5
Family households	80.3%	68.7%
Population below poverty level	5.8%	14.7%
High school or higher	86.9%	80.6
Population	5,842	3,642,361
Households	2,162	1,456,944

Figure 5-1: Tuttle Population and OESC Projections



5.1.6 COMMERCE DEPARTMENT POPULATION PROJECTIONS

The ODC/Census Bureau model predicts that the historical growth trend will continue through the year 2030. The Tuttle population is projected to increase from 4,294 to 5,220 by the year 2030. This is an average increase of 31 new citizens per year. Concurrently, Grady County is projected to increase from the 2000 population of 45,516 to a population of 55,300 in the same time period.

Figure 5-1 shows the historical population of Tuttle and the ODC projections extended to 2060. The projections result in a Tuttle population of 6115. Unfortunately, these projections are not useful since the current 2009 population of Tuttle is estimated to be over 6000. Consequently other estimating methodologies have been developed and described below.

5.1.7 POPULATION PROJECTION METHODOLOGY (SIMILAR CITIES PROJECTION)

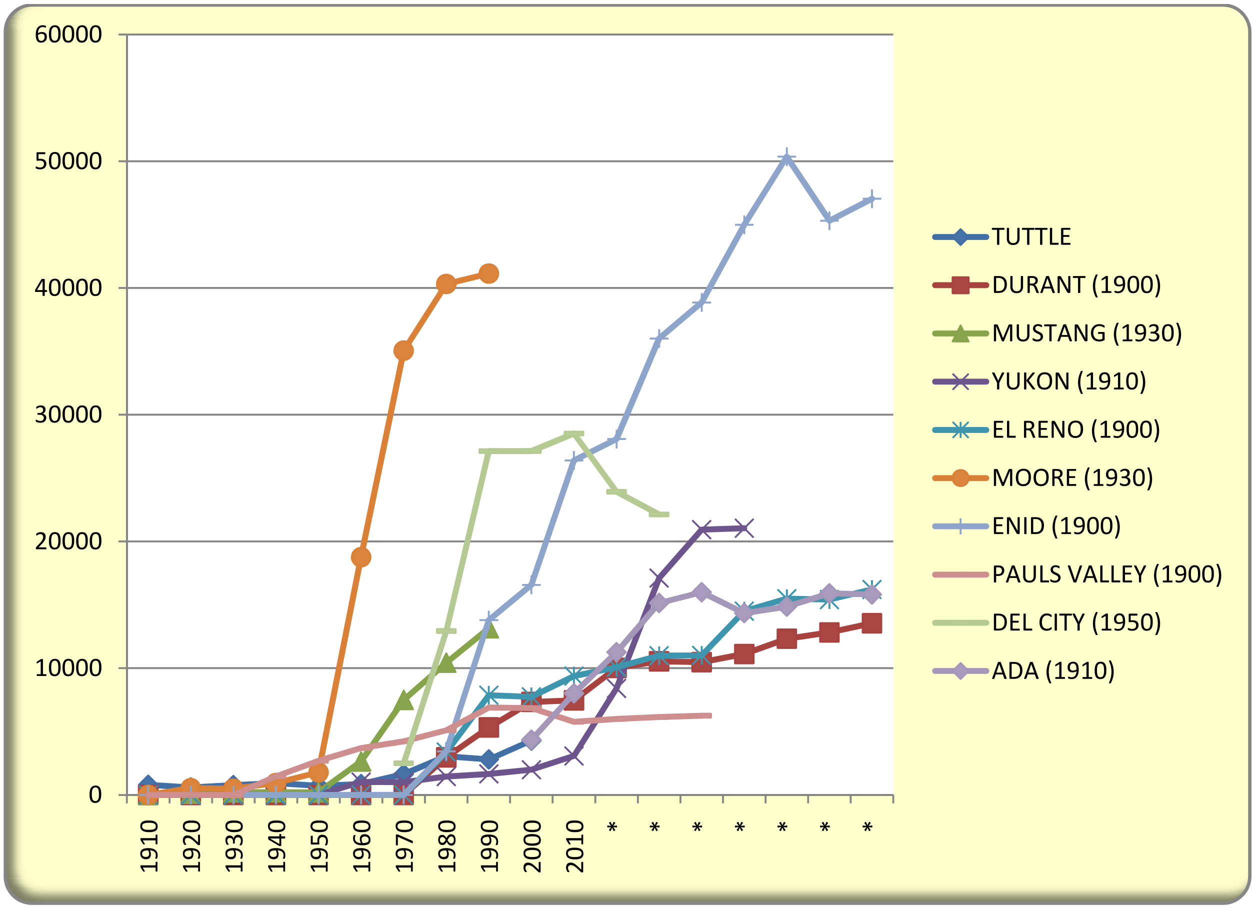
Another recognized method used in population projections is termed a "Similar Cities Projection." Essentially, cities of the same size or larger are selected for analysis. At some point in the development of these communities each had a population identical to Tuttle. Graphically, the population curves are adjusted in time to the point where the populations coincide. For example, the populations of most significant Oklahoma communities were approximately 750-1000 between 1900 and 1930. The population graphs were shifted to coincide with Tuttle's population of 715 in 1950. The populations of the various cities are shown in Figure 5-2.

The logic behind this model is straightforward. The management and citizens of Tuttle are familiar with the communities presented in the model. Therefore, it is easy to visualize the events that occurred in these communities that led to growth. From this graph it is evident that relatively high rates of growth are possible. The next step is to reasonably project if the circumstances that catalyzed high growth in other cities will also apply to Tuttle.

The "similar cities" that attained populations between 20,000 and 100,000 had one or more of the following occur:

- Introduction of a major military installation (Midwest City, Lawton, Enid).
- Growth of a major University (Norman, Stillwater).
- Industrial growth (Bartlesville).
- Proximity to a Standard Metropolitan Statistical Area [SMSA] (Midwest City, Norman, Mustang).
- A less obvious "growth" catalyst (Muskogee).

Figure 5-2: Similar Cities Population Analysis



It is probably fair to assume that neither a new military installation nor a new major university is likely to locate in Tuttle. Future population growth is occurring and will continue to occur because of several factors:

- Completion of the Canadian River Bridge in late 2001 and completion of SH 4 to SH 37 in October 2002. This significantly improved access to Tuttle and provided a corridor for new residents desiring to commute to parts of the Oklahoma City SMSA.
- Low cost of living.
- Interest in the local topography of rolling hills, creeks, the South Canadian River, etc.
- "Saturation" of other cities in the SMSA and a desire to live in a rural setting relatively close to a metropolitan area.

Other Tuttle demographic advantages include low crime rate, low poverty, relatively high income, etc.

5.1.8 DENSITY ANALYSIS

As a continuation of the similar cities analysis, a density analysis was also performed. The densities of various Oklahoma municipalities were determined and are shown graphically in Figure 5-3.

This technique enables Tuttle stakeholders to gain a perspective of the characteristics of various communities. Most Tuttle citizens are familiar with the communities shown and can visualize the future Tuttle as a dense community such a Del City, or a more rural community such as El Reno or somewhere in between.

5.1.9 CITY COUNCIL AND STAFF INPUT

It is difficult, and arguably unwise, for an "outsider" to produce a population projection without the involvement of the council and City staff. A cross-section of the populace has both objective and subjective knowledge of the trends likely to shape Tuttle's future. A meeting was held on July 20, 2009, with members of the City staff. The population input from that meeting is summarized below:

- The City is at a unique crossroads. It can grow rather dramatically, or using zoning, regulations and other techniques, can limit growth.
- At the present time there is no consensus regarding the vision for the ultimate Tuttle. Some older residents are very happy with the historic rural nature of Tuttle and would prefer low or no growth. Newer residents would prefer growth and the convenience of increased commercial development and services. Other citizens are somewhere in between.
- There is a consensus that no one prefers a high density Tuttle.
- Development will initially continue along the SH 4 corridor and will sequentially move west in the future.
- Industrial expansion is a low priority and if it does occur would be most probably located north of Englebretson Lane and east of North Cimarron Road and near rail access.
- Tuttle appears to be experiencing a growth pattern similar to the growth experience by Mustang, just to the north; virtually no growth through 1970, then dramatic growth (2,637 to 13,156) in the next 30 years.
- Some level of cooperation with Bridge Creek is likely in both the near future and long term.
- Commercial development will occur along SH 4 and SH 37.
- The current comprehensive plan does not reflect what is likely to happen in the future.

Figure 5-3: Population Densities, Various Oklahoma Municipalities

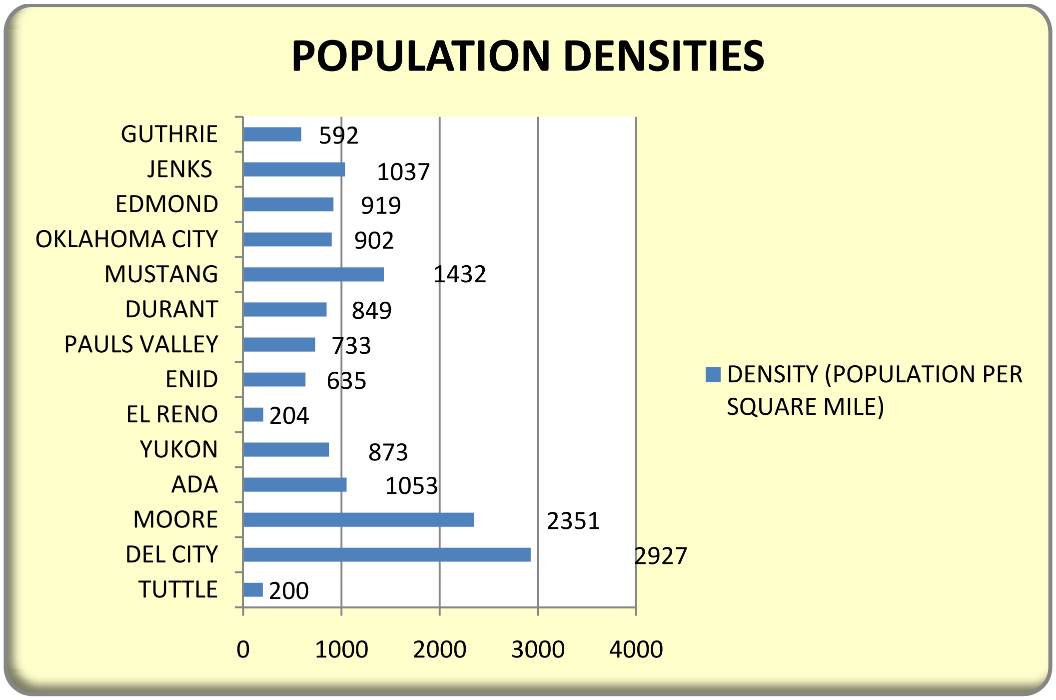
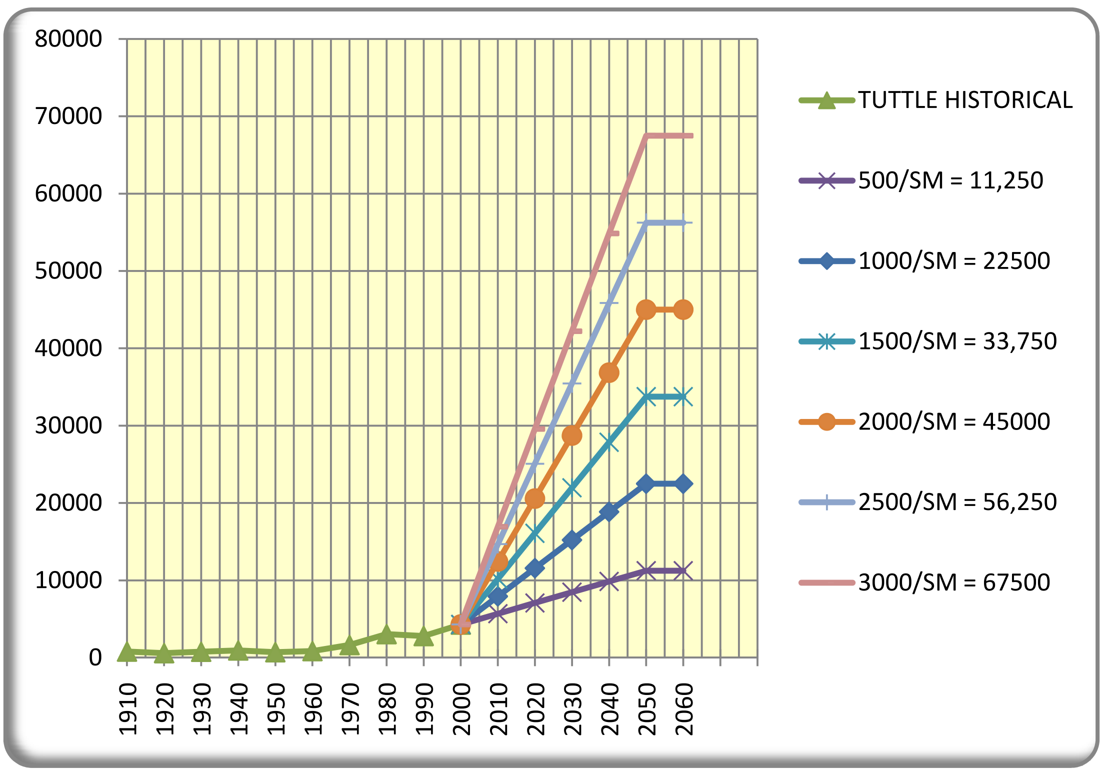


Figure 5-4: Tuttle Density Analysis



Considerable discussion occurred concerning the vision or "feel" for the future Tuttle. It was concluded that a population density of 1500 people per square mile would preserve the open feel of Tuttle while also providing the advantages of a medium sized municipality. For the purposes of wastewater system planning, it is assumed that the growth will occur in the next 40 years. After 2050 Tuttle will have achieved ultimate "build-out" and the population will remain flat. Using the density of 1500 people per square mile and the available usable area (i.e. outside of the floodplain) of 22.5 square miles, it is projected that the ultimate Tuttle will have a population of 33,750. Figure 5-4 shows the population for various assumed densities.

5.2 PLANNING POPULATION DISTRIBUTION

To enable estimation of the size of sewers required in the future to serve the planning ultimate population (Section 8.1.5), it is necessary to estimate the spatial distribution of population that will occur within the City. A population density of 1500 people per square mile will be the average density across the City, but there will be variations in population density in different parts of the City.

Currently the City has two population distribution patterns. In Old Tuttle residential housing is located on small lots, whereas residential growth in the eastern half of the City has occurred on large residential lots; therefore the population density increases from east to west. The lack of a public sewer has contributed to the development of larger lots in the eastern half of the City, but the installation of a sewer system will encourage denser housing development (Section 8.1). As future development is likely to occur westward towards Old Tuttle, a future population distribution pattern has been developed that reflects an increasing population density from west to east.

The area of the City outside of the floodplain is 22.5 square miles (Section 4.4). The vast majority of the floodplain is north of Silver City Ridge Road, with some narrow floodplains occurring along the creeks south of the road. In developing the future population distribution pattern for wastewater planning purposes, it was therefore decided to distribute the planning ultimate population on land south of Silver City Ridge Road. Since the average population density is 1500 people per square mile, it was decided that the population density would range from 1000 at the eastern edge of the City to 2000 at the western edge of the City. The population density was then assigned to each section of the City and multiplied by the buildable area per section area to give a population per section. The population assumed for each City section and its corresponding population density is given in Table 5-2, and a graphical representation of the population distribution is given in Figure 5-5. Based upon this population distribution, the population of the City highlighted as residential development areas in the 2020 comprehensive master plan (i.e. east of Cemetery Road) would ultimately be 15,250.

In reality, it is unlikely that every residential household within the City will be connected to a future wastewater system. Of the estimated current City population of 6,000, only 900 residents in Old Tuttle are connected to the existing POTW, leaving 5,100 residents served by individual, on-site sewage treatment systems. Residents are likely to be unwilling to connect to a sewer system unless given an incentive or forced to by the City. In addition, collector sewers would need to be installed within existing housing subdivisions, which may have layouts that are not suitable for installing sewers.

Table 5-2: Planning Population Distribution by Section

Section	Buildable Area (mi²)	Planning Population	Planning Population Density
1,T9N,R5W	0.5	500	1,000
1,T9N,R6W	0.6	1,100	1,833
2,T9N,R5W	0.5	500	1,000
2,T9N,R6W	1	2,000	2,000
3,T9N,R5W	0.5	750	1,500
3,T9N,R6W	0.4	650	1,625
4,T9N,R5W	0.5	750	1,500
5,T9N,R5W	0.5	750	1,500
6,T9N,R5W	0.5	750	1,500
25,T10N,R5W	0.5	500	1,000
25,T10N,R6W	1	1,750	1,750
26,T10N,R5W	1	1,000	1,000
26,T10N,R6W	1	1,750	1,750
27,T10N,R5W	1	1,000	1,000
27,T10N,R6W	1	1,750	1,750
28,T10N,R5W	1	1,500	1,500
29,T10N,R5W	1	1,500	1,500
30,T10N,R5W	1	1,500	1,500
31,T10N,R5W	1	1,500	1,500
32,T10N,R5W	1	1,500	1,500
33,T10N,R5W	1	1,500	1,500
34,T10N,R5W	1	1,500	1,500
34,T10N,R6W	1	2,000	2,000
35,T10N,R5W	1	1,000	1,000
35,T10N,R6W	1	2,000	2,000
26,T10N,R5W	1	1,000	1,000
36,T10N,R6W	1	1,750	1,750
	22.5	**33,750**	

Figure 5-5: City of Tuttle – Planning Population Distribution

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Development of large lots is also likely to continue in the eastern half of the City where a developer will probably install on-site treatment as opposed to a sewer system, as the housing density is such that the former is more economical to install.

For these reasons, it was decided to produce a map of the spatial distribution of population connected to the sewer network for wastewater planning purposes. In producing this map, three assumptions were made as to which parts of the City would most likely to be connected to the sewer system:

- Every household west of Frisco Road would be connected to the sewer network. Old Tuttle has a sewer network and can accommodate growth in its immediate area.
- Every household east of Sara Road would not connect to the sewer network, due to the continued development of large lots.
- The area between Frisco Road and Sara Road would consist of a mixture of connected and unconnected households. It was assumed that existing residential developments would remain unconnected, while all future residential developments would connect to the new sewer system.

Based upon the above assumptions, and also making an assumption as to the existing population for each section of the City between Frisco Road and Sara Road, the distribution of population connected to the sewer network is given in Figure 5-5. This gives a planning connected population of 24,500, which is 72.6% of the planning ultimate population.

5.3 PLANNING SEWER FLOWS

An estimation of sewer flows resulting from the predicted population is required in order estimate the size of sewers and the wastewater treatment facility. For planning purposes, the *Recommended Standards for Wastewater Facilities* (also known as the *"Ten State's Standards"*, or TSS) states that the sizing of wastewater facilities receiving flows from new wastewater collection systems shall be based upon an average daily flow (ADF) of 100 gallons per capita per day (gpcd), plus wastewater flows from industrial plants and major commercial facilities. The 100 gpcd value includes an allowance for normal infiltration into the sewer network. However, sewers must be sized (and treatment facilities designed) to handle the peak flows. In TSS, the peak flow can be calculated from the average flow using the following equation, where P is the population served in thousands of people at a particular point in the network:

$$\frac{Q_{peak}}{Q_{ave}} = \frac{18+\sqrt{P}}{4+\sqrt{P}}$$

The City has very little existing industrial plants or major commercial facilities. Industrial development is a low priority for the City (Section 5.1.9) and flows generated by a major commercial development are dependent upon the nature of that development, and the development may or may not generate more sewage than residential housing occupying the same land area as the development. For these reasons, it was decided to calculate sewer flows based on the 100 gpcd value and the residential population. The calculated average and peak flows for both the planning connected population and the planning ultimate population are given in Table 5-3.

Table 5-3: Planning Sewage Flows

Planning Scenario	Population	Average Daily Flow	Peak Flow
Connected Population	24,500	2.450 MGD	6.283 MGD
Ultimate Population	33,750	3.375 MGD	8.192 MGD

For the purpose of this study, it was decided that the conceptual sewers would be sized (Section 8.1.5) on flows calculated using the planning ultimate population, while the conceptual wastewater treatment facility would be sized (Section 0) on flows calculated using the planning connected population.

For sewer sizing, as discussed, it is unlikely that all of the future population of the City will be connected to the sewer system. However sizing the sewers on the planning ultimate population provides spare capacity to handle additional unplanned flows, such as extending the sewer system into Bridge Creek or flows from a major commercial facility with high water usage. However, in sizing the wastewater treatment facility, it is better to size it using the flows that are likely to occur and expand the facility should higher flows occur, than to oversize the facility for flows that may not occur, given the capital expenditure involved in the construction of a facility.

6 EVALUATION OF TREATMENT PLANT ALTERNATIVES

6.1 APPLICABLE TREATMENT TECHNOLOGIES

6.1.1 OVERVIEW

Technologies for the biological treatment of wastewater can be divided into three treatment process categories based upon the amount of oxygen available to treat the wastewater. The three categories are:

- Aerobic – A treatment process that is dependent upon the presence of freely available oxygen.
- Anoxic – A treatment process that is dependent upon the absence of freely available oxygen.
- Anaerobic – A treatment process that is dependent upon the complete absence of oxygen.

Technologies based upon the aerobic treatment processes are the most commonly used in the treatment of domestic wastewater. In this process, the wastewater is aerated to promote the growth of microorganisms that can break down organic matter. The strength of organic matter in the wastewater is measured by a parameter known as Biochemical Oxygen Demand (BOD).

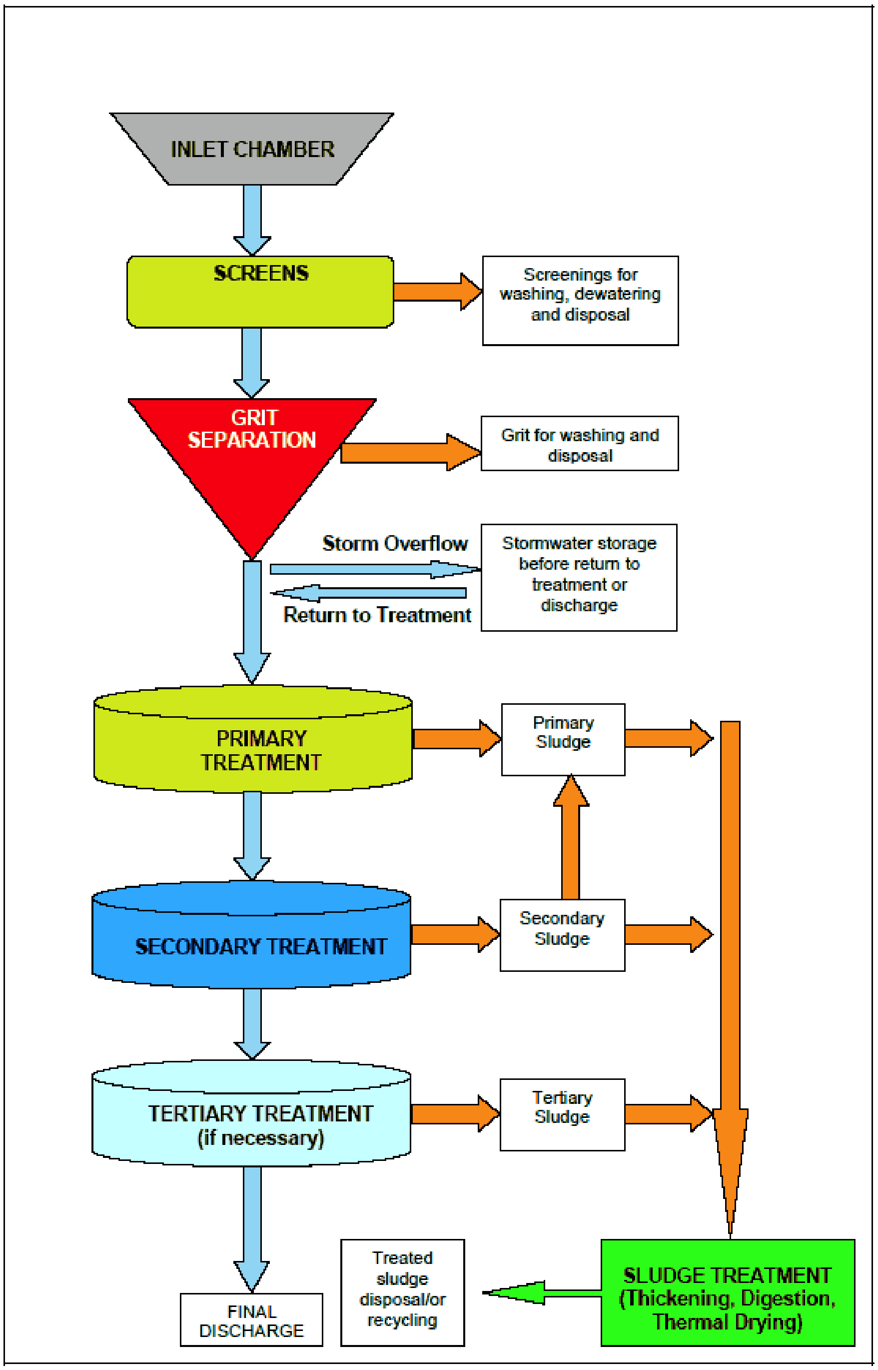
In aerating wastewater, any ammonia (NH_3) present is oxidized into nitrate (NO_3) through a process known as nitrification. In some situations, it is necessary to remove nitrate (denitrification) prior to the discharge of final effluent to a watercourse as it is a nutrient that promotes the growth of algae, which can affect water quality. Denitrification is achieved through an anoxic treatment process: the wastewater is unaerated and so microorganisms obtain their oxygen from the nitrate, hence the nitrate is converted into nitrogen gas.

Anaerobic treatment processes are most commonly used to pre-treat high strength organic wastes (which usually result from an industrial process) or to treat the sludge produced by an aerobic treatment process. They are also used to remove phosphate from domestic wastewater under the same circumstances as nitrate, as it also is a nutrient.

Treatment technologies can be also be divided into two growth processes: suspended-growth and attached-growth. In a suspended-growth process, the microorganisms are suspended within the wastewater they are treating; in an attached-growth process, the microorganisms are attached to an inert media, such as rock or plastic materials.

By far the most common aerobic suspended-growth system used in wastewater treatment is the activated-sludge process (Figure 6-1). There are many variations of the process in terms of flow and aeration regime, but each variation follows the same principles. Incoming wastewater passes through preliminary treatment (screens, grit removal) and is discharged into primary settling tanks, in which any settleable solids are removed. The settled wastewater is then discharged into an aerated activated-sludge reactor, which contains the microorganisms that carries out the biological treatment. The reactor is aerated either using diffused air or mechanical aerators. The discharge from the reactor contains a mixture (known as mixed liquor) of both treated wastewater and microorganisms. The mixed liquor is subsequently discharged into secondary settlement tanks to separate out the treated effluent from the microorganisms, which form sludge. The treated effluent is discharged from the top of the settlement tank and the sludge is drawn from the bottom of the tank. Since microorganisms have been removed from the reactor, sludge has to be returned to the reactor (returned activated sludge, or RAS) to maintain the bacteria population, and the RAS is usually mixed with the incoming settled wastewater at the inlet to the reactor. Since the reactor promotes the growth of microorganisms, the sludge removed from the settlement tank is in excess of that required to be returned, therefore a percentage of the sludge is wasted (waste activated sludge, or WAS) to the sludge treatment facility.

Figure 6-1: Typical Activated Sludge Flow Schematic



Aerobic attached-growth systems operate within the same treatment sequence (preliminary treatment, primary settling, biological treatment and secondary settling) as suspended-growth systems. The difference is that the microorganisms are attached to a media and the settled wastewater generally flows through a media bed (as with a trickling filter, Figure 6-2) or the media is partially submerged and rotated within the wastewater (as with a rotating biological contactor, Figure 6-3).

Figure 6-2: Schematic of a Trickling Filter

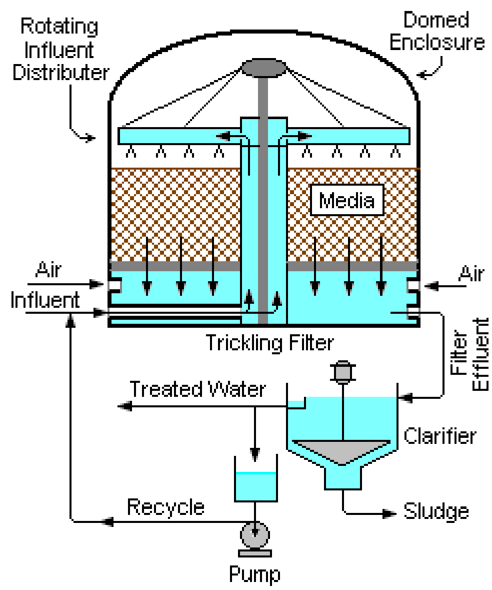
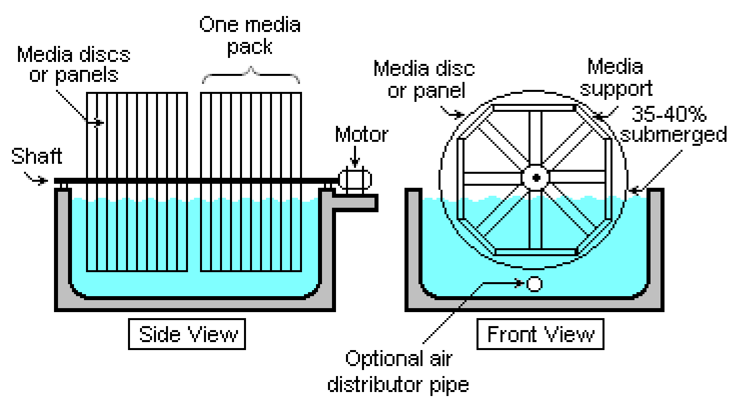


Figure 6-3: Schematic of a Rotating Biological Contactor
(From http://static.newworldencyclopedia.org/3/3c/Rotating_Biological_Contactor.png)



The media is generally aerated using natural aeration. The media can be fully submerged, in which case aeration is achieved using diffused air. As the microorganisms are fixed to the media, the discharge from the system is treated effluent and not mixed liquor and so separation of microorganisms from the treated effluent is not required. However as the film of microorganisms on the media increases, a process known as 'sloughing' occurs where excess microorganisms is washed off the media, and so secondary settlement is required to settle out sloughed microorganisms.

Wastewater can also be treated in lagoons, where settlement and biological treatment occur simultaneously. The most common type of lagoon used in wastewater treatment is the facultative lagoon. Incoming flows are screened prior to discharge to the lagoon. Settable solids fall to the bottom of the lagoon to form an anaerobic sludge layer. At the surface of the lagoon, the presence of sunlight and aeration by wind action promotes the growth of algae in an aerobic zone. In between the two zones is a facultative (aerobic-anaerobic) zone, which is populated by microorganisms that can survive in either aerobic or anaerobic conditions. The algae produce oxygen that is used by both the aerobic and facultative microorganisms in the breakdown of organic matter. Another type of lagoon is the aerated lagoon, where the lagoon is aerated (using surface aerators or mixing pumps) to ensure that the full depth of the lagoon is aerobic. In some situations, removal of algae in the treated effluent is required; this can be achieved through the use of a polishing lagoon or fine screens.

6.1.2 DISCUSSION WITH ODEQ

A meeting was held with ODEQ (Appendix A) on April 17, 2009 to obtain their thoughts regarding the construction of a wastewater treatment facility for the City. Results from the meeting will enable the study to highlight and address any concerns and issues raised by ODEQ for this study.

The main concern of ODEQ is the discharge of treated effluent to the Canadian River and the discharge standard any future plant would have to meet. The discharge standard would be dependent upon the Wasteload Allocation Study (WLAS) currently being undertaken by the Association of Central Oklahoma Governments (ACOG) and the Canadian River Project Group (CRPG) (see Section 6.1.3); the results of this study would affect the selection of the appropriate treatment technology.

ODEQ stated that it is quite possible that a future treatment plant would have a seasonal discharge permit to the Canadian River. Under such a permit, the discharge of treated effluent to the river would be permitted during periods of high river flows (e.g. winter, spring) but prohibited during periods of low river flows (e.g. summer, fall). During these prohibited periods, the treated effluent would be disposed through evaporation or land application.

Evaporation is achieved through the use of total retention lagoons. These are lagoons with no discharge outlet, and that are sufficiently sized to retain all incoming sewage flows and provide sufficient surface area to allow for the rate of evaporation to exceed the incoming flows. Total retention lagoons do not require a discharge permit but do require a large area of land relative to other treatment technologies; for this reason they are limited in use to individual houses on a large lot or very small communities, commercial operations or industries. For this reason, their use in a future treatment plant for the City would be impracticable; however, they could have a role to play in the interim. The City could construct relatively inexpensive total retention lagoons to provide treatment for a limited number of initial customers who connect into a new sewer system until the WLAS has been completed and a discharge standard determined. This would allow the City to commence construction of a new wastewater treatment system without delay.

In land application, the wastewater is treated to a sufficient standard such that effluent can be discharged onto the ground for treatment or reuse. The effluent is further treated via percolation through permeable soils, or is used to irrigate pasture land, hay meadows or crops that will not be eaten raw. If the effluent is disinfected, it could also be used for landscape irrigation e.g. golf course. The effluent is usually applied to the ground by spray or drip irrigation. ODEQ indicated that Braum's Dairy Farm (which is located to the west of the City) could be interested in obtaining treated effluent from the City for land application.

Treatment technologies that are acceptable to ODEQ and that could produce a treated effluent that could be discharged to the river or disposed through land application include:

- Facultative Lagoons
- Partial-Mix Aerated Lagoons
- Any activated-sludge process, including Oxidation Ditches, Membrane Bioreactors (MBR) and Sequencing Batch Reactors (SBR)
- Rotating Biological Contactor (RBC)

All the above technologies are listed in the regulations regarding the construction of a wastewater treatment facility[6] with the exception of MBR; however ODEQ indicated in the meeting that MBR is acceptable. ODEQ also indicated that the use of trickling filters is not acceptable.

A partial-mix aerated lagoon is an aerated lagoon that provides aeration only to maintain aerobic conditions, but does not provide sufficient energy to keep all total suspended solids (TSS) in suspension.

An oxidation ditch consists of an oval or ring shaped channel equipped with mechanical surface aerators. Screened wastewater (primary settlement tanks are usually excluded) enters the ditch and is aerated as it circulates around the ditch, with mixed liquor removed from the ditch at the opposite end to the inlet. Secondary settlement tanks are used to settle the mixed liquor to separate out the microorganisms. The ditch is normally operated in what is known as extended aeration mode, where the wastewater is aerated for a longer duration when compared to a conventional activated sludge process.

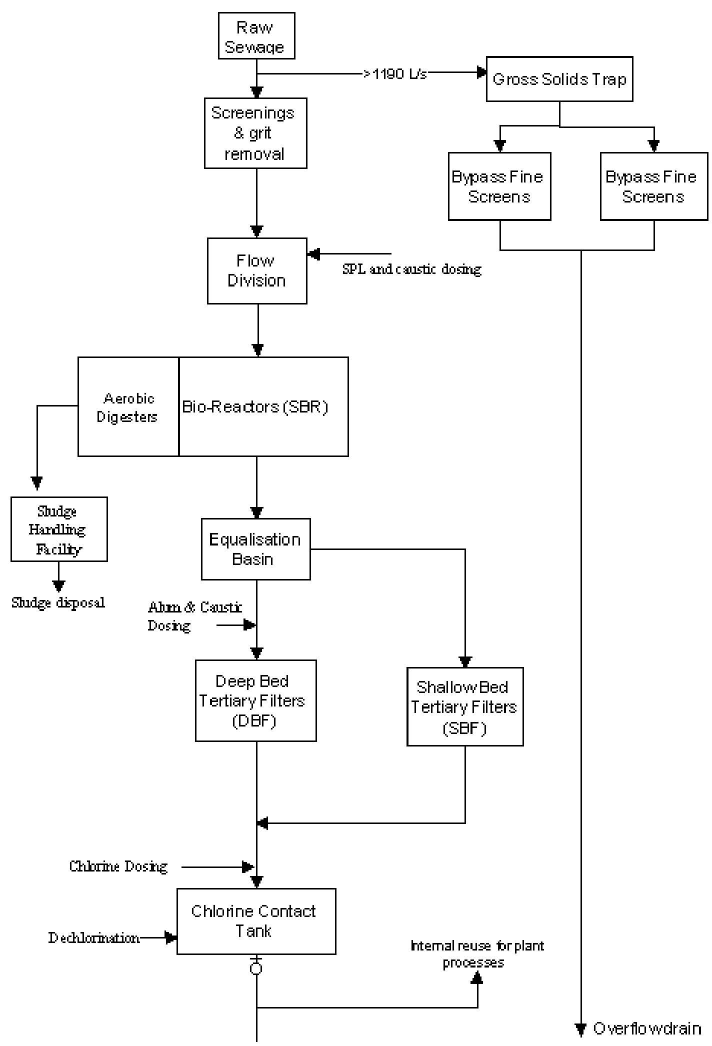
In the MBR process, settlement of the mixed liquor is achieved using a membrane process (ultrafiltration or microfiltration) as opposed to settlement tanks. The membranes were originally installed within a separate chamber to the reactor, but recent developments allow the membranes to be installed within the reactor. The benefit of using membranes is that the plant footprint can be reduced by the elimination of secondary settlement tanks, and the production of a higher quality effluent due to increased removal of solids. Fouling of the membranes occurs as they filter out microorganisms, so periodic cleaning of the membranes is required. As the microorganisms are retained in the reactor, a RAS system is not required and WAS is removed directly from the reactor.

[6] Oklahoma Administrative Code 252:656 '*Water Pollution Control Facility Construction Standards*'

The SBR process (Figure 6-4) is unique among all activated-sludge processes; in that it is a batch process, while all the other processes are flow-through i.e. wastewater and treated effluent enter and leave the reactor on a continuous basis. Typically the operation of an SBR reactor has five stages in a treatment cycle (Figure 6-5):

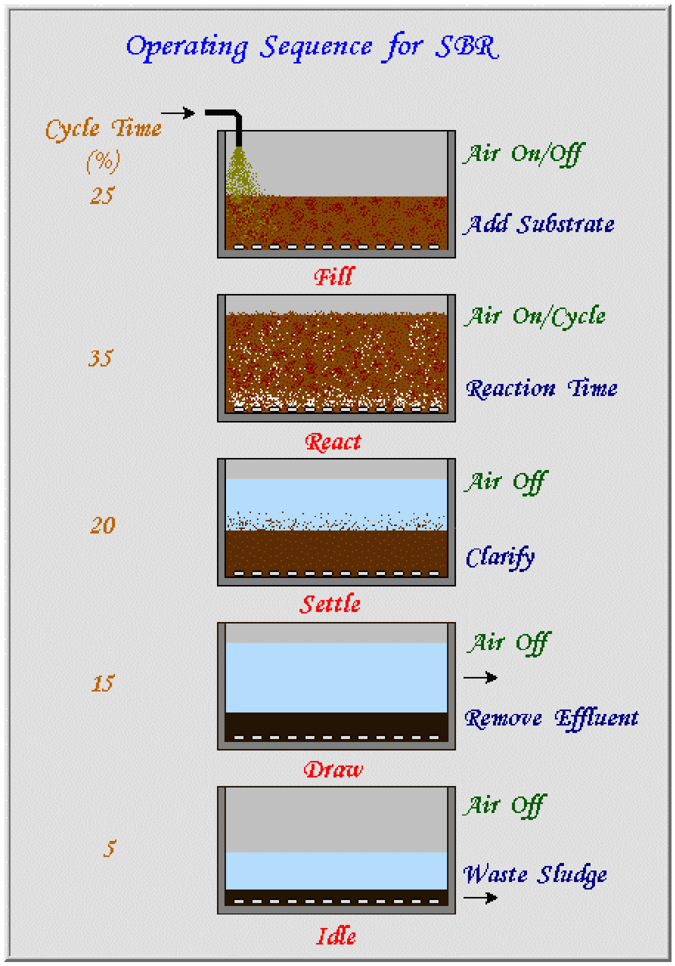
1. Fill: Wastewater enters the reactor
2. React: When full, flows into the reactor are stopped and the reactor is aerated
3. Settle: Aeration of the reactor ceases and the microorganisms settle to the bottom of the reactor
4. Draw: Treated effluent is decanted from the top of the reactor without disturbing the settled microorganisms
5. Idle: The reactor waits for the next Fill stage. WAS is generally removed from the reactor in this stage.

Figure 6-4: Typical Sequencing Batch Reactor Flow Schematic



The SBR process requires a minimum of two reactors, with one reactor receiving wastewater flows while the other reactor is going through its treatment process. While the reactors are larger than those required for other activated-sludge processes, they benefit from the fact that primary settlement tanks are usually excluded (the incoming wastewater is still screened) and secondary settlement tanks are not require; a RAS system is also not required. The process is also flexible in that the time of each stage and the total cycle time can be adjusted to meet a variety of influent conditions and effluent requirements.

Figure 6-5: SBR Treatment Cycle
(From http://web.deu.edu.tr/atiksu/toprak/sbrsema.gif)



The RBC process consists of a series of closely spaced circular disks, which are usually made from polystyrene or PVC. The disks are partially submerged within the wastewater and rotated slowly through it (Figure 6-3). Aerobic conditions are maintained by the disks rotating through the air as they exit the wastewater and before they renter it. The rotation of the disks helps slough off excess microorganisms. Screening and primary and secondary settlement tanks are required with this process.

6.1.3 WASTELOAD ALLOCATION STUDY

ACOG and the CRPG are implementing a WLAS for the Canadian River from approximately Union City to Wayne, Oklahoma, a distance of about 80 miles. GUERNSEY, in association with FTN Associates, Inc., was selected by ACOG to perform this study. The intent of the study is to evaluate river flows and water quality, through data collection and modeling, to determine effluent limitations for the various communities that discharge municipal wastewater within this defined reach of the river. Future permits must reflect effluent chemistry and flows that will maintain water quality standards in the Canadian River. The entities being addressed include:

- Union City
- Minco
- ***Tuttle***
- Mustang
- Newcastle
- Oklahoma City
- Moore
- Norman
- Noble
- Purcell
- Lexington
- Lexington Department of Corrections
- Chickasaw Nation/Riverwind Casino

Phase I of the study was initiated in the autumn of 2008. The main activities included: (1) a comprehensive river reconnaissance to familiarize the WLAS team with river characteristics and the facilities that are discharging to the river, (2) preliminary desktop modeling, and (3) preparation of a Phase I Report and Quality Assurance Project Plan (QAPP). Phase II of the study is designed to perform two field studies, during low flow conditions, to collect data for the modeling and ultimate determination of effluent limitations for future permits. Phase II was supposed to occur in July and August of 2009, but due to some project process changes, will not be implemented until the summer of 2010.

At this writing, Phase I is not yet complete. The QAPP documentation is being readdressed and there are various discussions currently being undertaken by ODEQ and ACOG to obtain concurrence on the desired content of the QAPP. Subsequent to QAPP approval by ODEQ and ACOG, the QAPP will be provided to the Oklahoma Secretary of the Environment for their submittal of the QAPP to the US Environmental Protection Agency (EPA) Region 6 for review and comment. It is anticipated that this review and approval process will extend until the end of 2009.

Assuming Phase II field activities take place in July and August 2010, it is most likely that effluent limitations for Tuttle will not be available until the end of 2010 or early 2011. After the 2010 field studies are conducted, modeling must be performed using the data collected from the two field studies. A Phase II report must be prepared and approved by ACOG, ODEQ, and EPA.

6.2 EVALUATION OF ALTERNATIVES

6.2.1 LAGOONS

Of the suitable treatment technologies mentioned in Section 6.1.2, both aerated and facultative lagoons can be discounted (except for the interim use) for a number of reasons:

- The City has stated that they would prefer a mechanical plant over lagoons as the permanent treatment solution.
- Facultative lagoons would require too much land. For flow-through lagoons based upon a final connected population of 24,500 (Section 5.2), a per capita BOD of 0.22 lb/person/day and a maximum organic load to the lagoons of 35 lb BOD per acre of water surface area per day, the required surface area of lagoons would be 154 acres. For partial-mix aerated lagoons, the maximum organic loading rate is 100 lb BOD per acre of water surface area per day, but this still would require 54 acres of lagoon.
- Neither facultative nor aerated lagoons can produce a good quality treated wastewater for discharge to an adversely affected water without additional treatment[7,8]. While both technologies can achieve BOD removal up to 95% and meet a typical BOD discharge consent of 30 mg/l, TSS concentrations can range up to 100 mg/l and additional settlement or filtration is required to achieve a typical TSS discharge concentration of 30 mg/l. In addition, neither technology can consistently remove ammonia through the nitrification process. Should an ammonia discharge limitation be imposed on the plant, additional nitrification treatment would be required.

6.2.2 ACTIVATED SLUDGE TECHNOLOGIES

The major advantages and disadvantages of the three activated sludge technologies (oxidation ditch, MBR, SBR) are given in Table 6-1. This table was derived from information contained within the EPA Wastewater Technology Fact Sheet for each technology. Based upon the relative merits of the three technologies, the fact sheets state the applicability of each technology, which is summarized in Table 6-2.

The three technologies can be compared to each other based on a number of parameters: cost (construction and operational), operation, maintenance, sludge production, process flexibility and effluent quality.

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[7] EPA Wastewater Technology Fact Sheet *'Facultative Lagoons'*

[8] EPA Wastewater Technology Fact Sheet *'Aerated, Partial-Mix Lagoons'*

Table 6-1: Merits of Alternative Activated Sludge Technologies

Technology	Advantages	Disadvantages
Oxidation Ditch	Low operational requirements and operational and maintenance costs. Long hydraulic retention time and complete mixing minimize the impact of a shock load or hydraulic surge. Produces less sludge than other activated sludge processes due to extended biological activity. Energy efficient operations result in reduced energy costs compared with other activated sludge processes.	Effluent suspended solids concentrations are relatively high compared to other activated sludge processes. Requires a larger land area than other activated sludge processes, limiting their feasibility in urban, suburban, or other relatively high land cost areas.
MBR	Operate at higher volumetric loading rates, requiring less space than a conventional system. Produces high quality effluent.	Higher capital and operating costs than conventional systems for the same throughput, due to membrane cleaning, fouling control and eventual replacement. Higher energy costs due to air souring of membranes. WAS may have poor settling characteristics.
SBR	Equalization, primary settlement, biological treatment and secondary treatment can be achieved in a single reactor, producing a minimal footprint and potential capital cost savings. Operational flexibility and control – can be set up for nutrient removal without requiring additional tanks. No RAS system required. Effluent suspended solids concentrations are lower compared to other activated sludge processes.	Higher level of control sophistication and maintenance associated with controls, switches and valves when compared to other activated sludge processes. Potential of discharging settled sludge in the Draw phase with some configurations. Depending upon aeration system, potential plugging of aeration device during selected operating cycles. Depending on downstream processes, potential requirement for flow equalization after the SBR.

Table 6-2: Application of Alternative Activated Sludge Technologies

Technology	Application
Oxidation Ditch	Effective in small communities, as it requires more land than conventional treatment plants. Plants that require nitrification, as the basins can be sized using an appropriate sludge retention time to achieve nitrification.
Membrane Bioreactor	High-quality effluent requirements, such as reuse applications and for surface water discharge applications requiring extensive nutrient removal.
Sequencing Batch Reactor	Flow rates of 5 MGD or less, as more sophistication is required for larger plants. Effective in areas where available land is limited, due to relatively small footprint. Where nutrient removal may be required in the future, since the treatment cycle can be easily modified for nutrient removal. If tertiary treatment (e.g. filters) is required after the biological stage, as SBR are very cost effective.

Due to their long hydraulic retention times, oxidation ditches require larger reactors and more land than the other two processes and therefore are most likely to incur the highest construction cost. MBR eliminates the need for secondary treatment but requires the installation of membranes. SBR is most likely to incur the lowest construction cost as numerous treatment processes can be accommodated within one reactor.

In terms of operation and maintenance (O&M) of the three technologies and their respective O&M costs, MBR are most likely to have the highest costs due to the need to keep the membranes clean and to prevent fouling. All MBR systems:

- Require pumping to force the wastewater through membranes.
- Require 1-3 mm fine screens up front of the membranes to reduce the chance of damage, and the screens require frequent cleaning.
- Use air scour to reduce the buildup of material on the membranes.
- Use cleaning solutions (e.g. bleach, citric acid) to clean the membranes and maintain the life of the membranes.
- Require the replacement of membranes at some point in the future (typically after 7-10 years).

Since the operation and maintenance requirements for membranes are a specialty, there is the requirement to employ higher qualified operational staff or to provide training to existing staff.

Due to their flexibility and the consolidation of several processes in one reactor, the maintenance requirements of SBR may be more intense than the other systems due to additional valves and switches to control the process. However, labor and maintenance are reduced elsewhere since there are no primary or secondary settlement tanks and no RAS system to maintain. Since the SBR treatment cycles are flexible and can be changed for difference circumstances, operator training is required in modifying operational control parameters e.g. changing aeration or process time for each stage of the cycle.

Oxidation ditches are probably the easiest of the three to operate and maintain, since the only major piece of equipment is surface aerators; however secondary settlement tanks and a RAS system will need to be maintained. As oxidation ditches operate in extended aeration mode, it will consume more oxygen (1.8 lb O_2/lb BOD) than other activated sludge processes (SBR require 1.4 lb O_2/lb BOD).

As oxidation ditches operate in the extended aeration mode, less sludge is produced (typically 0.5 lb/lb BOD removed) than a plant operating in a conventional activated sludge mode (typically 0.75 to 0.95 lb/lb BOD removed). This will lead to smaller sludge handling facilities and less sludge for disposal. SBR have the flexibility to operate in different activated sludge modes and so the amount of sludge produced is dependent upon how the SBR is operated. Any activated sludge process can be equipped with membranes to turn it into a MBR process, and so sludge production is dependent upon the mode of operation. However MBR removes colloidal particles that are not normally removed by secondary settlement tanks since these particles do not settle easily; this produces a sludge that does not settle as good as sludge produced from a settlement tank. Additional chemical treatment is required to increase the settleability of the sludge.

In terms of process flexibility, the SBR is a very flexible process. It can be set up to simulate any activated sludge process, including nutrient removal. For example, by varying the holding time in the React stage, the SBR can operate in the extended aeration mode. For nutrient removal, both anoxic and anaerobic conditions can be achieved at different times within the treatment cycle that allows for nitrate and phosphate removal without requiring additional tank volume that a conventional activated sludge process would need. Although membranes have no great flexibility in their operation, they are flexible in that they can be used with any activated sludge process to produce a MBR system. Oxidation ditches are designed to operate in one activated sludge mode (extended aeration), and if a ditch was set up for BOD removal but nutrient removal was required in the future, the ditch would require modification to enable denitrification to be achieved.

The use of membranes in a MBR results in removal from the treated wastewater particles that are not removed by a secondary settlement tank; therefore an MBR produces the highest quality effluent of the three technologies. Typically, BOD and TSS concentrations are in the range 1-2 mg/l. With a conventional secondary settlement tank, wastewater is flowing through the tank as the settlement process occurs; however in a SBR settlement occurs under quiescent conditions, therefore the treated wastewater is of a slightly higher quality. A typical SBR effluent would have BOD and TSS concentrations of 10 mg/l or less. With an oxidation ditch using secondary settlement tanks, typical BOD and TSS concentrations would be 10 mg/l and 15 mg/l or less.

Table 6-3: Ranking of Alternative Activated Sludge Technologies

Parameter	Rank Value		
	Oxidation Ditch	MBR	SBR
Construction Cost	3	2	1
Operational Cost	2	3	1
Operation	1	3	2
Maintenance	1	3	2
Sludge	1	3	2
Process Flexibility	3	2	1
Effluent Standard	3	1	2
Total	**14**	**17**	**11**

From this comparative discussion, each technology has been ranked from 1 to 3 on the parameter discussed. The rank values are given in Table 6-3 along with a total rank value, with the lowest total rank value representing the most appropriate technology when all of the advantages and disadvantages have been taken into account. Based on the assigned rank values, the SBR technology would appear to be slightly more favorable technology than oxidation ditches or MBR. It should be noted that the assigned values are subjective since they are based on generalities; therefore since each treatment plant is different and it is not known at this stage what treatment standard has to be met or the constraints placed upon its design; one of the other two technologies could be viewed as being more favorable as the project proceeds on from feasibility into design. In addition, no weighting has been applied to the parameters as to their importance in the final selection of a technology.

SBR technology has been used extensively by communities throughout Oklahoma to treat their wastewater. Communities with populations over 10,000 where SBR plants are in use, under construction, or are planned include:

- Ada
- Ardmore
- Bethany-Warr Acres
- Del City
- Durant
- Guymon
- Miami

- Moore
- Mustang
- Oklahoma City (Cow Creek WWTP)
- Tahlequah

6.2.3 ROTATING BIOLOGICAL CONTACTORS

In comparison to activated sludge processes, RBC plants are simpler to operate and have lower maintenance and power consumption[9]. Since the disks are naturally aerated, there is no aeration system to maintain and no associated power consumption. This saving is partially offset by the power required by motors to rotate the disks and the maintenance associated with the motors and shaft bearings. In addition there is no requirement for a RAS system. The lack of aeration and RAS systems reduce the amount of process control and instrumentation (e.g. dissolved oxygen sensors) to operate the plant. A consequence of the above is that less skilled personnel are required to operate the plant.

An RBC system also requires less land than a conventional activated sludge plant of equal capacity. The system has been standardized such that one RBC unit contains 100,000 ft^2 of disk housed on one shaft rotating within a 12,000 gallon tank, and with a typical side wall depth of 5 ft, the footprint of one unit is only 320 ft^2. As the typical hydraulic loading rate is 2 $gal/ft^2/d$, one RBC unit can treat 200,000 gallons per day. However capital costs will tend to be higher than for a similar sized activated sludge plant.

The main disadvantage of RBC units is that they have a history of operational problems, such as shaft failures, media breakage, bearing failures and odor problems[10]. Shaft failures have been attributed to metal fatigue and excessive accumulation of microorganisms on the media. Media breakage has been attributed to exposure to heat, organic solvents or ultraviolet light. In both cases, inadequate structural design has also been a contributing factor. Bearing failures have been attributed to inadequate lubrication. Effort has been made by RBC manufacturers to correct these problems. RBC units are currently installed at the City of Moore POTW, but operational problems experienced there have contributed to the decision by the City to install an SBR plant. Ardmore recently deactivated an RBC plant and constructed a new SBR process. Midwest City is currently performing an engineering evaluation to change from RBCs to an alternate technology.

The RBC units are installed in stages that act in series, and the first stage can become overloaded, which can result in low dissolved oxygen and the development of hydrogen sulfide due to the presence of the filamentous bacteria *Beggiatoa.* This problem can be overcome by providing a supplemental air supply.

In regards to nutrient removal, denitrification can only be achieved with the installation of additional RBC units in which the disks are fully submerged within the wastewater. Biological

[9] From '*Handbook of Environmental Engineering Calculations*' by C. C. Lee, Shun Dar Lin

[10] From '*Wastewater Engineering*', 3rd Edition, by Metcalf & Eddy

removal of phosphate is not achievable with RBC units; if required, phosphate removal is achieved through chemical precipitation.

7 FACILITY LOCATION/SITE SELECTION

7.1 *SITING CRITERIA*

There are numerous criteria to consider in determining a suitable site for the location of a wastewater treatment facility. One of the most important criteria is the physical properties of the receiving stream. The size of the water course and the volume of treated wastewater to be discharged have an effect on the discharge standard that the facility has to meet. Sewage or effluent reaching a stream is consumed by microorganisms. This microbial action uses oxygen and produces a Dissolved Oxygen Sag. This oxygen deprivation can affect the esthetics of the watercourse and adversely affect wildlife. Nutrients in the wastewater can cause eutrophication which promotes aquatic plant growth and decay. This process effects esthetics and water quality. Solids and microbes/viruses in wastewater also can have detrimental affects downstream of the discharge. A facility that discharges a large volume of treated wastewater into a small stream has a significant impact on the small ecosystem and will have to meet a much higher discharge standard than a facility that discharges the same volume of treated wastewater into a large river. Larger watercourses simply have a greater assimilative capacity. Unfortunately, the closest major river to Tuttle has virtually no flow during the summer months and can effectively be both a major river and a small stream from a permitting standpoint.

The ideal situation is to locate a facility next to the largest available water course for direct discharge. If an available site is not close, then usually the treatment facility is located close to the community it serves to minimize the sewer system, and the treated wastewater is pumped to a discharge location.

Locating a facility at the downstream end of a water course that flows through or near a community usually infers that it is located at elevation lower than the community it serves. At such a location, a sewerage system can be laid out such that sewage can flow under gravity from the community to the facility, so minimizing the need to pump sewage uphill to the treatment plant. In addition, the treated wastewater discharge point also needs to be downstream of a community's water intake if a water course is used as the raw water supply.

Locating a facility at the downstream end of a community usually means that it is located on the edge of or just outside the community. This solves a lot of problems that can occur when locating a facility more central in the community. Sufficient land may not be available within the community to construct a facility due to development having already occurred, whereas the downstream edge of a community is likely to be less developed and have more available land. Any available land within the community is also likely to have already been zoned for other use (e.g. residential or commercial development) and so constructing a plant on it would be incompatible with its intended use.

The development of a treatment facility within a community also has to overcome the public perception that it is an unwanted development that should not occur anywhere near where its citizens live. This situation is commonly referred to as "not in my back yard" (NIMBY). Citizens usually have concerns over such issues as the plant's visual impact, the potential for odors and traffic movement. Most states regulate how close a treatment facility can be located next to existing residential development. The visual impact of a facility can be minimized by selecting a site that is in a low-lying area, as it is less visually obtrusive and easier to screen with existing or planted trees when compared to a location that is more visually obtrusive e.g. on top of a hill. The visual impact of a facility can also be reduced by partially burying tanks, etc., but this increases construction costs. Treatment facilities can be designed to minimize odor production and to capture and treat generated odors, but odors can never be fully eliminated. By regulating the distance between a facility and residential development, buffer zones are established that may be effective in isolating odors from developed areas. Another control is to locate the facility in an area where the prevailing winds are away from the community. With these concerns in mind, locating a facility on a site as far as practicable from existing development areas is the optimum solution.

Situating a facility beside a water course in an area away from existing development does present its own set of issues. The land alongside a river is prone to flooding and there is usually a floodplain. While a treatment facility can be built within the floodplain, it has to be designed so that tanks and equipment are not flooded by the 100-year flood, which usually means having to raise structures; this increases construction costs and its visual impact. Building on the floodplain can also restrict the passage of flood waters, thus raising upstream water elevations that could lead to larger areas being flooded. For these reasons, it is better if the site is located outside of the floodplain.

Undeveloped land alongside a river can also exhibit wetland characteristics or habitat for threatened and endangered species, and so locating a site in these areas can raise more environmental issues that if the site was located in an already developed area. Such issues have to be investigated and any mitigation measures agreed to that will counterbalance any negative impacts the plant may have before the development can occur. It is therefore preferable to select a site that has no major environmental issues.

A treatment facility requires vehicular access and utilities (electricity, gas, water, telephone etc.) to function as intended. It is preferable to locate the site where such infrastructure is already in place or close by; otherwise the community will have to spend additional funds to extend the infrastructure out to the site.

In summary, the ideal site for a wastewater treatment facility should have the following features:

- Located downstream and downwind of a community beside a large water course but outside of the floodplain
- Situated away from existing development to reduce visual and odor impact, but with existing infrastructure nearby and not located within an environmentally sensitive area.

In reality, very few potential sites will meet all of the above criteria, and so each site has to be evaluated to determine their individual merits and constraints; the selected site will then be the location with the most merits and fewest flaws, or with restrictions that can be mitigated through the design opportunities.

7.2 CONSTRAINTS AND OPPORTUNITIES

In determining appropriate sites within the City for a wastewater treatment facility, there are several constraints that must be taken into consideration. The ideal location for a facility would be relatively close to the Canadian River for the direct discharge of treated wastewater to the river. However the presence of floodplains along the river may limit locating a plant near the river. In addition, the course of the Canadian River does change over time. This can be illustrated by comparing the course of the river shown on topographic maps produced in the 1960's (Figure 4-3) against current aerial photographs (Figure 4-1). A discharge point that is on the river when the plant is constructed may be some distance from the river sometime in the future. ODEQ has indicated that locating a discharge near the mouth of a creek that discharges into the Canadian River would be acceptable and should not impact the final discharge standard; such discharge would be considered as being directly to the Canadian River.

City staff has stated that they would like the wastewater treatment facility to be located as close as practicable to the proposed commercial development areas along SH 4. This highway has more traffic volume than SH 37 and so the installation of a sewer in this area would help to stimulate commercial development, which in turn will increase tax revenue. However this constraint provides an opportunity. SH 4 runs through the area of the City earmarked for residential development, and so the development of a sewage system to serve the commercial development areas would also be well placed to serve residential development.

Another constraint is that ODEQ regulations require that any wastewater treatment facility must be located at least 100 ft from the nearest residence. Consideration must also be given as to the areas where future residential development is anticipated, such that the separation distance does not impinge future development.

One sewage disposal opportunity relates to the presence of Braum's Dairy Farm, located just beyond the western edge of the City. The farm operates numerous center pivot irrigators to irrigate fields along the banks of the Canadian River for the production of hay. There is the opportunity to provide Braum's with treated wastewater for irrigation such that a discharge to a river is not required. This would provide more flexibility in locating a facility, since it could be moved further away from a water course. The agricultural land that is in the floodplain in the northwest corner of the City is also a suitable location for the land application of treated wastewater.

The predominant wind direction in central Oklahoma is from the south; therefore the ideal location for locating a facility would be on the north side of town with regards to mitigation of odor concerns. Since the land in the City slopes northward toward the Canadian River, there is the opportunity to locate a facility that minimizes both the requirements for lift stations to pump sewage and the potential for odor-related problems.

7.3 EVALUATION OF SITES

Given the criteria set out in Section 7.1 and the constraints and opportunities identified in Section 7.2, the most logical site for a water treatment facility that would best meet these requirements would be located near the mouth of one of the creeks that discharge into the Canadian River. As discussed in Section 4.2, there are seven creeks flowing through the City that discharge to the river. The evaluation of sites along these creeks is presented in the following sections.

7.3.1 WEST CREEK

West Creek is located on the western edge of the City, between Gregory Road and Cimarron Road. The creek flows north and joins Store Creek north of Silver City Ridge Road. Store Creek continues north and turns east when it reaches the Canadian River floodplain. From there it flows approximately ½ mile before turning north when it reaches Cimarron Road and flows along the western edge of the road for approximately ¾ mile to the Canadian River.

The best location for a wastewater treatment facility (i.e. on the edge of the floodplain) is located outside of City's corporate boundary, and so City utilities would need to be extended to the site. The surrounding area is undeveloped agricultural land with a few isolated properties and it is immediately downstream of the existing City lagoons; therefore it would be relatively easy to take the lagoons out of service and divert the flows to the new facility. However the location is approximately 5.5 miles west of SH 4, and of the seven creeks under consideration would be the farthest site away from the City's desired location. In contrast, the site is only two miles from the Braum's Dairy Farm.

7.3.2 EAST CREEK

East Creek is located on the east side of Old Tuttle and flows approximately along the line of Richland Road. The creek flows north until it reaches the Burlington Northern & Santa Fe (BNSF) railroad, where it turns approximately east-northeast to parallel the railroad. From there it flows directly to the Canadian River. The creek enters the Canadian River floodplain at the intersection of Richland and Silver City Ridge Roads; therefore this general area may be suitable for a wastewater treatment facility. However, the creek still has to flow approximately 2.5 miles to the Canadian River and is 4 miles west of SH 4.

Possible facility locations also exist in the floodplain. At the northern end of Cemetery Road and just south of East Creek, the Flood Insurance Rate Map (FIRM) shows two 'high' spots that are above the 100-year flood elevation and are located approximately ½ mile from the Canadian River. The sites are also closer to SH 4, which is approximately 2 miles to the east. The surrounding land is undeveloped, well away from any existing residential development and so visual impact and odor issues should not be a problem. The land surrounding the sites would be suitable for land application if such a disposal method were required.

The floodplain locations do have potential obstacles to development that could be overcome through engineering:

- The Canadian River could shift course and move towards the two locations. Any facility built here would have to be protected from the potential erosion effects of the river.
- Access to the facility would be via Cemetery Road that would be underwater should a 100-year flood occur. The road could be raised but the current FIRM does not have flood elevations, so it is not known by how much the road has to be raised.
- The area of land above the 100-year flood elevation may not be large enough to accommodate a treatment facility without importing earth to raise the elevation of surrounding land.

7.3.3 WORLEY CREEK

Worley Creek is located in the central section of the City, generally between Cemetery Road and Czech Hall Road. The creek flows north into the Canadian River floodplain before turning east to discharge into the river. The point where the creek enters the floodplain is approximately 1 ¼ miles west of SH 4 and approximately ¾ mile upstream of its discharge point. Residential development has occurred on the east side of the creek, with the edge of one housing addition within 1/3 mile of the creek. The west side of the creek is less developed and consists of agricultural land with a few scattered farm buildings. Worley Creek has the largest drainage basin within the City (Figure 7-1), therefore placing a treatment facility in the lower reaches of this creek can allow for the construction of a gravity sewer system that would serve the largest area without the requirement for pumping.

7.3.4 INDIAN CREEK

Indian Creek flows along the west side of SH 4, and so a treatment facility in the lower reaches of this creek would be ideally located to serve both commercial and residential development areas identified in the comprehensive master plan. In addition, since the river flows along the foot of the bluffs at this point, the floodplain is quite narrow (less than 500 ft), and so the discharge point of a facility located on the edge of the floodplain would be very close to the river.

The lower stretches of the creek create some obstacles to the development of a facility. It would be located within an area that has been identified for commercial development, so the amount of developable land would be reduced. Due to the construction of the bridge, SH 4 north of Silver City Ridge Road is located within a cut and the creek has been diverted such that it flows along the edge of the highway, and the bridge commences at the edge of the floodplain. A facility could be constructed alongside the highway, but it would be on a slope and visually obtrusive when viewed from the highway. If a facility was built on land outside of the cut as to be unseen from the highway, it would be close to existing residential development and where future residential development could occur.

7.3.5 UNNAMED CREEK 1

There is a small, unnamed creek that discharges into the Canadian River approximately ½ mile east of SH 4. The land north of Silver City Ridge Road is undeveloped and could be a potential site for a treatment facility. The edge of the floodplain is located outside of City's corporate boundary, and so City utilities would need to be extended out to the site.

One constraint is that the creek has a very small drainage basin; the creek is no more than 1 ½ miles long. Placing a treatment facility in the lower reaches of this creek would lead to a very limited gravity sewer system that would require extensive pumping to bring in flows from other parts of the City located in the other drainage basins.

Figure 7-1: City of Tuttle – Drainage Basins

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7.3.6 COAL CREEK

Coal Creek is located in the eastern half of the City and generally flows along the line of Sara Road, and is approximately one mile east of SH 4. Currently the creek discharges into the Canadian River at the edge of the floodplain; therefore in theory the lower reaches of the creek have good potential for locating a facility close to the river. However, there are some obstacles to the development of a site in this area. The creek is situated in a wide valley which has its own floodplain, which is relatively wide at it joins the floodplain of the Canadian River.

In addition, there has been and continues to be high profile residential development along the creek between the Sara Road and the edge of the floodplain all the way downstream to Silver City Ridge Road. Therefore there is a lack of suitable sites that are both out of the floodplain and away from residential development.

7.3.7 UNNAMED CREEK 2

The second, unnamed creek that discharges into the Canadian River is located close to the eastern edge of the City and approximately two miles from SH 4. The land around the creek at the edge of the floodplain is undeveloped and appears to possess virtually all of the conditions listed in Section 7.1 for the ideal location of a wastewater treatment plant. It is at the most downstream location in the City, and it may be possible to install a gravity sewer system to serve most of the City. This could be achieved by installing trunk sewers down each creek valley that discharge into an interceptor sewer that flows from west to east along the edge of the floodplain downstream to the site. This is dependent upon the slope of the interceptor sewer that can be achieved, and it is likely that a lift station would be required to pump sewage over the bluffs between Worley Creek and Coal Creek if a suitable route along the foot of the bluff cannot be found. The same sewer network can be used for all of the other creeks discussed in the previous sections, but they would all require a lift station on the interceptor to pump the sewage upstream to the treatment facility.

One potential drawback to locating a facility on this creek is the relatively long distance from the edge of the floodplain to the creek's discharge point. Once the creek reaches the Canadian River floodplain, it turns east and flows for approximately 3 miles before discharging to the river. Given this distance, ODEQ may not consider the treated wastewater discharge point to be at the mouth of the creek. This would require the facility to treat the sewage to a higher quality for discharge to the creek; alternatively, the treated wastewater may have to be pumped to a discharge point closer to the mouth of the creek, but this has the risk that course of the creek could change as it flows across the floodplain.

The creek also flows by the City of Newcastle water treatment plant. The plant is served by four groundwater wells located on the banks of the Canadian River that draw water from the alluvial aquifer, and the creek flows within approximately ½ mile of the closest well. While the creek discharges into the river downstream of the wells, the City of Newcastle may perceive the discharge of treated wastewater into this creek as a cause for concern with regards to the quality of their water supply.

7.4 CONCLUSIONS/RECOMMENDATIONS

From the evaluation of the seven drainage systems for potential sites to locate a wastewater treatment facility, four of the creeks can be classified as having little potential for various reasons:

- West Creek – Too remote from the planned commercial and residential development areas. Would require a lot of sewage pumping since it is the farthest upstream creek.
- Indian Creek – Lack of suitable land, as the creek is located within the proposed commercial development area and residential development has occurred in surrounding areas.
- Unnamed Creek 1 – Limited opportunity for a gravity sewer system.
- Coal Creek – Lack of suitable land that is outside of the floodplain and away from residential development.

East Creek, Worley Creek and Unnamed Creek 2 offer the greatest potential for locating a treatment facility. Each one of them has a distinct advantage including:

- East Creek has potential sites out of the floodplain above the 100-year flood elevation, close to the Canadian River and well away from any existing residential development.
- Worley Creek has the largest drainage basin, thus providing a good opportunity to minimize pumping, and is the closest site to where development is planned to occur.
- Unnamed Creek 2 has the most potential to have an entirely gravity fed sewage system.

Against these advantages, the potential disadvantages must be taken into consideration. Any East Creek location out on the floodplain would require additional engineering work to ensure that the site and access to it are protected from flood waters and movement of the river. Any Unnamed Creek 2 location may be too far from the mouth of the creek to warrant consideration of the discharge of treated wastewater as being directly to the Canadian River; therefore treatment may be required to meet a more stringent discharge standard. In addition, objections could be raised by the City of Newcastle.

Of the three potential creeks, only Worley Creek has no apparent disadvantages. For this reason, it is recommended that the lower reaches of Worley Creek be considered to be the primary area for the City to locate a wastewater treatment facility, with East Creek and Unnamed Creek 2 considered secondary location areas.

Due to the delay of WLAS study (Section 6.1.3), the City may not know what discharge standard a new wastewater treatment facility is required to meet until late 2010 or early 2011. One way for the City to proceed with the development of a wastewater treatment system is to land apply the treated wastewater. In this scenario, East Creek would become more favorable than Unnamed Creek 2. There is more available land within the City's corporate boundary around East Creek that could be used for land application than Unnamed Creek 2, and the City of Newcastle may object to land application occurring upstream of their water supply wells.

To identify any possible environmental constraints on the development of a wastewater treatment facility, a search of state and federal environmental databases was undertaken by Banks Environmental Data, who produce an Environmental FirstSearch™ Report. A copy of this report is contained within Appendix B. In producing this report, a search is made to identify known environmental concerns (e.g. wetlands, landfills, hazardous waste sites, historic sites etc.) within a given radius of a target property. Depending upon the database, the search extends ¼ mile, ½ mile or 1 mile from the target property. For this report, the target area was taken to be the lower reaches of both East Creek and Worley Creek. This area is shown in Figure 7-2 along with the ¼ mile radius around the search area.

The results of the search reveal that there are no documented environmental concerns that could have a major impact on the selection of a facility site. The National Wetlands Inventory database highlighted some wetlands on the Canadian River floodplain, but none were shown at the potential East Creek sites.

Figure 7-2: Environmental FirstSearch™ Area

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8 CONCEPTUAL PLAN

Any plan must be economically viable and affordable. The dilemma facing Tuttle is that the current rate payer base is too small to finance a major capital project. This reality demands a phased approach to financing and construction. A conceptual plan has been produced that would allow the City to construct an initial 'low-cost' sewer system and wastewater treatment facility, which would then expand as growth occurred in the City and new residential and commercial customers connected to the treatment system. The purpose of the plan is to allow the City to commence the installation of the system with minimal construction funding as possible, and then to expand the system as revenue generated from connected customers increase. The funding of the system is discussed in further detail in Section 9.

The conceptual plan can be split into three major components: (1) the long-term development of the sewer system, (2) the long-term development of the wastewater treatment facility and (3) the initial sewer and facility development. The following sections describe each major component in detail and how the initial installation could be achieved.

8.1 LONG-TERM DEVELOPMENT OF SEWER SYSTEM

Following discussions with City staff, it was decided that the long-term development of a sewer system should be divided into three broad phases:

- Phase 1 – To serve the commercial development areas along SH 4 and SH 37 identified in the 2020 comprehensive master plan.
- Phase 2 – To serve the residential development areas identified in the 2020 comprehensive master plan.
- Phase 3 – To serve the remainder of the City, including Old Tuttle that is served by the current POTW.

The installation of a sewer system under Phase 1 should encourage commercial development to occur along the major transportation corridors. For example, the installation of a sewer system in conjunction with the recent City improvements to the water supply system and the given volume of traffic may encourage the development of relatively large retail operations. While commercial development itself will not generate significant revenue from sewer rates, an increase in sales tax revenues would help to fund future expansion of the treatment system.

The installation of a sewer system under Phase 2 should encourage residential development, in particular more dense development. Under current ODEQ regulations, an individual on-site sewage treatment system (e.g. septic tank) is allowed to be installed on lot sizes as small as ½ acre (depending upon the method of disposal of treated wastewater and the presence of a public water supply). Due to the lack of a sewer system, the eastern part of the City so far has developed with large lots with on-site treatment, leading to low density residential development. However, for the City to fund the development of the wastewater system, higher density residential development is required to create a sufficient large customer base. Note that the term high density is relative. At 1500 people per square mile the residential lots can still be ½ acre to one acre in size. With a sewer system in place, such developments can occur.

The installation of a sewer system under Phase 3 would allow the City to divert sewage flows to the new treatment facility and close the current POTW. As discussed in Section 4.5, the existing lagoons have spare capacity; therefore they can currently handle the flows of any development occurring in and around Old Tuttle. This allows the City to concentrate on providing a sewer system to those areas not currently served by such a system before expenditure is required to divert the flows to the new treatment facility.

The conceptual plans for each phase of sewer system development are discussed in the following sections, and are based upon the following basic concepts:

- A wastewater treatment facility will be located in the lower reaches of either Worley Creek or East Creek.
- Trunk sewers will be constructed along the creek valleys to allow for gravity flow from south to north across the City. The trunk sewers will discharge into an east-west interceptor sewer located roughly along the edge of the floodplain that will transport sewage to the wastewater treatment facility, either under gravity flow or by pumped flow.
- With the basic trunk sewers in place, developers can install a sewer network to a serve a development and tie it into a trunk sewer.

8.1.1 PHASE 1 SEWER DEVELOPMENT

The area of interest in developing Phase 1 is along SH 4 from the Canadian River south to SH 37, and east and west along SH 37 from its intersection with SH 4. The topographic map of the area (Figure 4-3) shows that the high spot along SH 4 exists halfway between Tyler Drive and SH 37. North of this area, the land falls north along Indian Creek and Unnamed Creek 1; south of this spot the land falls southwest to Coal Creek. In addition the land along SH 37 in this area also falls towards Coal Creek.

One concept in developing Phase 1 is shown in Figure 8-1. Starting at the high point on SH 4, a sewer flows south alongside the highway to SH 37, where the sewer turns east until Cole Creek is reached. The sewer then flows alongside the creek to a lift station located on Tyler Drive. The length of this sewer is approximately 12,600 ft. Also from the high point, a second sewer flows north alongside the highway to a lift station located at the intersection of Silver City Ridge Road. The length of this sewer is approximately 7,500 ft. The Tyler Drive lift station pumps sewage along Tyler Drive via a force main (approximately 5,700 ft) to discharge into the north sewer. The Silver City Ridge Road lift station then pumps the combined north and south sewer flows to the wastewater facility.

The above initial development represents a spine that allows for future expansion of the system to serve the entire City east of SH 4. Locating a lift station on Tyler Drive besides Coal Creek has the benefit of allowing a large part of the Coal Creek drainage basin to be connected to the sewer system using gravity sewers. The lift station therefore provides a focal collection point towards which future gravity sewers should flow. To connect most areas east of Morgan Road to the system will require secondary lift station(s) to get sewage flows to the Tyler Drive lift station.

Figure 8-1: Phase 1 Sewer Development Concept

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Figure 8-2: Phase 2 Sewer Development Concept

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8.1.2 PHASE 2 SEWER DEVELOPMENT

The 2020 comprehensive master plan (Figure 4-5) shows residential development occurring east of Cemetery Road. The sewers installed under Phase 1 would serve residential development on the east side of SH 4 but not on the west side of the highway.

The concept Phase 2 development therefore provides an initial sewer system to the residential development area located between Cemetery Road and SH 4.

In Phase 2 of the development, the concept is to install trunk sewers along the main branch of Worley Creek and along an eastern tributary of the creek in the vicinity of Czech Hall Road (Figure 8-2). The length of the main branch sewer is approximately 14,500 ft and the length of the east branch sewer is approximately 9,200 ft. Depending upon the location of the wastewater treatment facility, sewage would either flow under gravity or be pumped to the treatment site. Since the flows from Phase 1 are pumped, it makes sense to discharge these flows directly into the facility head works without combining them with flows from Phase 2.

8.1.3 ALTERNATIVE PHASE 1&2 SEWER DEVELOPMENT

An alternative concept is provided that changes the sequence of installation so that some residential development west of SH 4 can connect to a sewer system during Phase 1 by delaying commercial development along a section of SH 4 to Phase 2. In this concept, Phase 1 consists of the south sewer on SH 4 from the original Phase 1 is combined with the sewer along the east branch of Worley Creek from the original Phase 2; the Tyler Drive lift station then pumps sewage via a force main to the Worley Creek east branch sewer. Phase 2 then consists of the north sewer on SH 4 and lift station and force main on Silver City Ridge Road, and the Worley Creek main branch sewer.

In this concept (Figure 8-3), only the section of SH 4 closest to SH 37 is initially provided with a sewer, with the assumption that commercial development will radiate from the intersection of the two highways and therefore the sewer in the northern section of SH 4 will not be immediately required. In compensation, residential development occurring along Czech Hall Road has immediate access to a sewer, thus increasing the potential for the City to obtain revenue from sewage rates at an earlier stage in the project to help fund Phase 2.

This alternative concept does however require the installation of an additional length of force main. The forcemain from the Tyler Drive lift station would discharge into the Worley Creek east branch sewer in the vicinity Czech Hall Road, increasing the length of the main from approximately 5,700 ft in the original Phase 1 to approximately 10,800 ft.

8.1.4 PHASE 3 INITIAL SEWER AND FACILITY DEVELOPMENT

The Phase 1 and Phase 2 sewer developments would allow the City to provide the basic sewer infrastructure to serve all the development areas highlighted in the 2020 comprehensive plan. As mentioned previously, it is projected that population growth will exceed that envisioned in the 2020 comprehensive plan. Any City development occurring outside of the Phase 1 and Phase 2 areas would require additional expansion of the sewer system. In addition, the City has an aim to eventually close the existing POTW and divert sewer flows to the new wastewater treatment facility.

Figure 8-3: Alternative Phase 1 & 2 Sewer Development Concept

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Figure 8-4: Phase 3 Sewer Development Concept

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In the conceptual Phase 3 development (Figure 8-4), sewage flows from Old Tuttle to the POTW will be intercepted at the last downstream manhole that receives incoming flows. A gravity sewer will divert the flows east towards East Creek, and then north along East Creek until it reaches Silver City Ridge Road. From there, the sewer turns east to flow along the toe of the bluffs to the wastewater treatment facility. The length of the sewer shown is approximately 26,000 ft, but it is dependent upon the exact location of the tie-in point and the facility.

The selected route allows for any development within the East Creek drainage basin to connect to the sewer system. With a sewer running along the edge of the floodplain, additional trunk sewers can be installed to serve any development occurring between Old Tuttle and Cemetery Road.

Figure 8-4 shows two potential trunk sewer routes that run along two tributary creeks of Worley Creek. One creek flows north between Richland Road and Frisco Road. A sewer here could be installed from Silver City Ridge Road up to the City's southern corporate boundary, the length of which is approximately 15,000 ft. Another creek flows north between Frisco Road and Cemetery Road, and another sewer of approximately 15,000 ft long would run from the City's southern corporate boundary to Silver City Ridge Road.

8.1.5 SIZING INFRASTRUCTURE

For each phase of sewer development, an estimate was made of the population each section of trunk sewer would serve, which is given in Table 8-1.

Table 8-1: Sewer Phase Population

Sewer Phase	Ultimate Population	Connected Population
Phase 1	10,250	4,000
Phase 2	5,300	3,000
Phase 3	18,200	17,500
Total	**33,750**	**24,500**

From the ultimate population, the average daily flow (ADF) and the peak hourly flow (PHF) were calculated for each sewer (Section 5.3). The trunk sewers were then sized using the following basis of design:

- The PHF due to the ultimate population.
- The average slope of the sewer along its entire length, based upon the conceptual routes shown and topography obtained from USGS maps.
- A Manning pipe roughness coefficient of 0.013 (a design requirement of ODEQ).
- A minimum pipe diameter of 8 inches (a design requirement of ODEQ).
- A minimum velocity of 2 ft/s at PHF (a design requirement of ODEQ).

- The depth of flow in the pipe at PHF is approximately 70% of its diameter.
- Standard pipe diameters would be selected i.e. a 15-inch diameter pipe would be selected if calculations suggested that a 13-inch diameter pipe would be suitable.

Force mains were sized to handle pumping of the PHF but achieve a minimum velocity of 2 ft/s when pumping at the ADF. Lift stations were sized on the PHF.

Using the above basis of design allowed for the trunk sewers and force mains to be conservatively sized so that the cost estimates should be conservative. In addition it allows for parts of Bridge Creek to the south to be connected to the trunk sewers. In reality the City may initially install smaller sized sewers and force mains and upsize them (either by replacement or by installing a parallel sewer) as development dictates. The size of the sewers and force mains for the three conceptual phases of development are shown in Figure 8-5. The sewer and force main sizes for the alternative Phase 1 and Phase 2 development are shown in Figure 8-6.

8.2 DEVELOPMENT OF WASTEWATER TREATMENT FACILITY

The first step in the development of a wastewater treatment facility is to determine the land requirements of a facility to treat the 2060 planning connected population of 24,500 (Section 5.2). From the conclusions drawn from the evaluation of treatment technologies (Section 6.2), it was decided to size the treatment facility based on the use of SBR technology.

8.2.1 ESTIMATION OF LAND REQUIREMENTS

The design ADF for the planning connected population is 2.45 MGD (Table 5-3), with a PHF of 6.283 MGD; therefore research was undertaken for information on SBR facilities of a similar size to determine how much land was required. Two such facilities were found:

- Pima Utility Wastewater Treatment Facility, Sun Lakes, AZ
- Northeast Treatment Plant, Guymon, OK

The Sun Lakes, AZ, facility (Figure 8-7) has design ADF of 2.4 MGD and a design PHF of 4.8 MGD. The facility consists of inlet works, three SBR reactors, a post-SBR equalization basin, filters, UV disinfection, three aerobic sludge digesters and centrifuges for sludge thickening and dewatering. The effluent from the facility is discharged to recharge wells and the sludge is disposed at a landfill site. Further information on the plant is contained within Appendix C. The total area of the entire facility is approximately 4 acres.

The City of Guymon, OK, is currently constructing a 3 MGD facility designed to handle a PHF of 9 MGD, with the inlet works designed to handle 12 MGD. The facility is utilizing the same SBR supplier (Siemens) as the Sun Lakes, AZ, facility. The facility is being constructed with inlet works, four SBR reactors, a post-SBR equalization basin, two aerobic sludge digesters, a gravity belt sludge thickener and a belt filter press to dewater sludge. Space has been allocated for future filters and UV disinfection.

Figure 8-5: Concept Sewer and Force Main Sizes

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Figure 8-6: Alternative Concept Sewer and Force Main Sizes

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Figure 8-7: Pima Utility Wastewater Facility

(From http://www.water.siemens.com/SiteCollectionDocuments/Product_Lines/Jet_Tech_Products/Brochures/JT-SUN-CS-0108.pdf)

From the above, an area of 5 acres would appear to be adequate for a mechanical plant; however the City should purchase additional land that would be required for a FEB and potentially a treated effluent holding lagoon. It is unlikely that a FEB would be used at all during the early years of the facility since the sewer network will be new and infiltration will be minimal; however as the sewer system ages, infiltration into the pipes and manholes is likely to increase. A treated wastewater holding lagoon would only be required if the City was going to land apply the treated wastewater.

For the future ADF of 2.45 MGD, initial sizing estimations were made for a FEB and a treated wastewater holding lagoon in order to establish how much land the City should purchase for a treatment facility. From these estimations, it is recommended that the City purchase a minimum of 20 acres, although purchasing more land would be preferable if it was available.

8.2.2 PHASING OF FACILITY DEVELOPMENT

One potential route to develop the wastewater treatment facility would be to initially install lagoons at the chosen facility site to handle a small connected population. As the connected population grows, a SBR facility could then be constructed in phases and the lagoons converted into a FEB and/or treated wastewater holding lagoon. An initial SBR facility would require at the minimum the installation of two SBR reactors, with each one capable of treating 100% of the flow to allow for one reactor being sequenced/out of service. The SBR facility could be expanded incrementally with the installation of additional reactors. For example, an initial 0.5 MGD plant would have two 0.5 MGD reactors. The installation of a third 0.5 MGD reactor would increase the plant capacity to 1 MGD with the allowance of one reactor out of service. The size and frequency of expansions would be dependent entirely on the pace of City development.

From the previous section, it can be seen that of the recommended minimum of 20 acres purchased for the facility, approximately 15 acres would be available for the development of initial lagoons. Based upon the relative sizes required for a FEB and a treated wastewater holding lagoon, one way to phase the development of the facility is as follows:

Phase 1a. Develop 5 acres of total retention lagoon system. To meet ODEQ regulations, two primary and two secondary lagoons would be required. This development would be able to serve a connected population of approximately 150 people. This would enable initial development of the sewer system while the WLAS is completed and the effluent permit limits for discharge to the Canadian River is finalized, or determination is made that land application is required during the summer months.

Phase 1b. If land application is required, or development of the City is slow, expand the total retention lagoon system by development of an additional 10 acres. A 15 acre total development would be able to serve a connected population of approximately 400 people. This step would require converting the existing four lagoons into two primary lagoons by demolishing the central dikes between the lagoons, and constructing two new secondary dikes.

Phase 1c. When the lagoons reach their treatment capacity, construct the first SBR phase. Convert one of the primary lagoons into a FEB and convert both secondary lagoons into treated wastewater holding lagoons. The second primary lagoon could be converted into a sludge drying lagoon for the dewatering of digested sludge, which would eliminate the need to install mechanical dewatering equipment.

The concept development of the treatment facility is given in Figure 8-8. At Phase 1b, if the City population was expanding rapidly <u>and</u> the use of land application was not required, the City could eliminate the expansion of the lagoons and go straight to Phase 1c, with the conversion of the 5-acre lagoons into a FEB and potentially a sludge drying lagoon.

One potential issue in using total retention lagoons is that they can only serve a small population for their size. It is possible that due to the pace of City development that Phase 1b and 1c must occur in quick succession after Phase 1a. One alternative would be for the City to install flow-through lagoons and land apply the treated wastewater, thus enabling the lagoons to treat higher flow rates. With flow-through lagoons, a 5-acre development would serve approximately 800 people, and a 15-acre development would serve approximately 1,900 people. This would enable the City to better space out each development step.

8.3 INITIAL SYSTEM DEVELOPMENT

The previous two sections have illustrated some concepts as to how the sewer network and the wastewater treatment facility can be developed over time. In planning for initial implementation of the system, one option would be to design and construct Phase 1 of both the sewer network and treatment facility. However, this would entail the City financing the construction of these capital projects but not being able to connect customers to the system and obtaining revenue from sewer rates until all of the Phase 1 improvements are in place. In addition, housing or commercial development may not occur unless the sewer is place, or development may go ahead but with individual, on-site sewage treatment, so that the potential revenue to the City is lost from that development.

One potential solution for the City would be temporary on-site sewage treatment to an entire development while the infrastructure is being installed to serve that development, thus enabling the City to obtain revenue from the development prior to the completion of the infrastructure.

As an example, a housing developer would install a sewer network to a housing development and terminate the sewer at a manhole located on the proposed alignment of a trunk sewer. The City would then install a truck mounted, packaged wastewater treatment unit at the manhole small enough that it could be delivered to site via road transportation. Flows from the housing development would then be pumped into the unit for treatment, and treated wastewater would be discharged into an above ground storage tank. The manhole would have to be deeper than required to create a storage volume into which a pump could be installed. The treated wastewater would then be pumped from the storage tank using a tanker truck and transported to a suitable land application site (or the existing POTW lagoons in wet weather). The unit would also be periodically desludged using a tanker truck and the sludge discharged at the inlet to the existing POTW. When financially capable, the City would install the trunk sewer up to manhole and backfill the excess depth with concrete to raise the bottom of the manhole to the required flow line.

A second option is to omit the package plant and install aerated tank(s). Aeration will keep the sewage "fresh" and provide some pre-treatment. The pre-treated sewage will then be trucked to the existing POTW lagoons and treated/discharged under the existing permit requirements.

With the connection of the development to the City sewer, the treatment unit and/or storage tank(s) would be removed from site and potentially moved to the next development. With the trunk sewer in place, any downstream development could be connected to the system, but any upstream development would require the extension of the trunk sewer, therefore the treatment unit could be reused to serve other developments. Should development occur at a pace that exceeds the City's rate of infrastructure installation, there may be a requirement for more than one treatment unit/tank-pump system to be located within the City.

While the sewer network is being installed to serve the development with the temporary treatment unit, the City would be developing an initial lagoon treatment system. If land for land application was available (or an agreement could be made with Braum's or other land owners to accept treated wastewater), the City could initially install flow-though lagoons and a land application system.

Figure 8-8: Concept Wastewater Treatment Facility

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Such a system typically consists of a center pivot irrigator that rotates around a central point. The treated wastewater would be pumped into the irrigator via a pipe coming up through the center of the pivot and flow along a header pipe that feeds spray nozzles. The header pipe is supported along its length by frames that have wheels attached to them at 90 degrees to the header pipe. The wheels are driven by motors such that the header pipe rotates as the wheels turn.

During this initial construction phase, the treated wastewater from the temporary treatment unit would be discharged via the outfall of the POTW until construction was complete. Treated wastewater from the temporary unit could then be discharged to the new lagoons, which would act as treated wastewater holding lagoons, while sludge would continue to be discharged at the POTW. When the sewer network was complete the lagoons would be switched over to treatment. There may be periods during the year when land application cannot occur due to wet weather; in such instances, the treated wastewater would be trucked to the POTW for discharge.

In purchasing a packaged wastewater treatment unit, there are three features that would be required for this application:

- The unit will have to be a complete treatment train contained within one tank.
- The unit can be delivered by road transportation and lifted onto a concrete pad, and hooked up to a feed pump and electricity supply.
- The unit can be picked up and moved to another location by road transportation.

After a search of manufacturer's literature, it was decided that a 50 ft long by 10 ft wide treatment unit was as large a unit as practicable that could be transported by road in one piece without requiring special transportation. Based on one manufacturer's literature (Pollution Control Systems, Inc.), such a sized unit is capable of treating 16,000 gpd, which is equivalent to the flow produced by 160 people at 100 gpcd. Based on an occupancy rate of between 3-4 people per house, one unit could serve between 80 – 120 houses. For larger housing developments a second treatment unit could be installed, although it is recommended that no more than two units are installed at one location since the installation begins to become obtrusive.

Should an aerated storage tank approach (no package plant) be used to save costs, consideration should be given to a canvas of used equipment suppliers. Since this is a temporary "stop-gap" measure to begin sewer development, it is not necessary to use or construct new tanks. Pre-owned oilfield tanks, used fiberglass reinforced (FRP) tanks, tank trucks at the end of their useful life, and other low cost options should be explored. Modification of the used tanks to add aeration, level control, alarms, etc would be a relatively minor expense.

8.4 ALTERNATIVE PHASE 1- PHASE 3 HYBRID OPTION

Ultimately the existing POTW lagoons will be connected to the new plant. Rather than building interim lagoons at the new plant site, consideration should be given to termination of the Phase 1 sewer at a sump and lift station at the new plant site. A force main will then be constructed from the plant site to the existing POTW. Sewage from new Phase 1 development will be treated in the existing 6 lagoons and discharged under the current NPDES permit requirements. The sequence of development changes from:

Temporary Aeration Tank/Package Plant

↓

Interim Lagoons

↓

Phase 1 Sewer Completion

↓

SBR Phased Plant Construction

↓

Phase 2 Sewer Construction

↓

SBR Plant Expansion

↓

Phase 3 Sewer Construction

To the following:

Temporary Aeration Tank/Package Plant

↓

Phase 1 Sewer Construction

↓

Concurrent Pump Station and Phase 3 Sewer Construction

↓

Phase 2 Sewer Construction

↓

SBR Plant Construction

When the plant is finally constructed the flow in the force main to the existing POTW can be reversed and the pipeline continued to be used to connect old Tuttle and decommission the existing lagoons. It is likely that the lift station can also be reused as part of the headworks for the new plant. The advantage is that the construction of the treatment plant can be deferred until the population (and rate payer base) increases 1000-2000 population. The hybrid plan also eliminates the need for interim lagoons at the plant site. These advantages are offset by the acceleration of the costs of the Phase 3 implementation.

9 PRELIMINARY FINANCIAL ANALYSIS

9.1 COST ESTIMATES

High-level cost estimates with contingencies have been produced for the development of the wastewater system. Cost estimates have been produced for both the long-term development of a sewer network, the long-term development of the wastewater treatment facility, and the initial sewer and facility development.

9.1.1 SEWER DEVELOPMENT COSTS

Unit costs were developed per linear foot (LF) of sewer and force main based on different diameters. In developing these costs, certain assumptions were made:

- The sewers and force mains would be laid either in road rights-of-way or across open countryside. A construction strip would be fenced off and the route cleared and grubbed. In addition, the topsoil would be stripped within the alignment and stockpiled for reuse in final construction.
- The average depth of excavation was taken to be 6 ft. The excavation would be open cut with 1:1 side slope.
- Manholes would be placed every 300 ft. The diameter of the manholes would be 4 ft for sewers of diameter up to 18 inches, and 6 ft diameter for sewers over 18 inches in diameter.
- The pipe material for both sewers and force mains would be PVC.

On top of the basic installation costs, other allowances were added, such as the cost to purchase easements, contractor overhead and profit (15% of base cost), engineering and construction overview (15% of base cost) and contingencies (20% of base cost) to cover such items as road crossings. The developed unit costs for sewers and force mains of different pipe diameters are given in Table 9-1.

The estimated costs to install the sewers, force mains and lift stations for each phase of the concept development is given in Table 9-2. These costs represent how much it would cost the City at 2009 prices to fully develop trunk and interceptor sewers to serve the entire City. The costs to fully develop these sewers based on the alternative Phase 1 and Phase 2 concept is given in Table 9-3.

Table 9-1: Sewer and Force Main Unit Costs

Pipe Size and Type	Unit Cost/LF
6″ force main	$91.91
8″ sewer	$132.22
10″ sewer	$161.67
12″ force main	$122.78
12″ sewer	$178.30
15″ sewer	$194.94
18″ sewer	$203.37
21″ sewer	$224.68
24″ sewer	$235.55
27″ sewer	$237.78

Table 9-2: Estimated Costs, Sewer Development

Development	Estimated Cost
PHASE 1	
10″ sewer (12,600 LF) to Tyler Drive Lift Station	$2,035,000
Tyler Drive Lift Station	$500,000
12″ force main (5,700 LF) from Tyler Drive Lift Station to SH 4	$700,000
8″ sewer (2,220 LF) on SH 4 south of Tyler Drive	$295,000
15″ sewer (5,280 LF) on SH 4 north of Tyler Drive	$1,030,000
Silver City Ridge Road Lift Station	$500,000
12″ force main (7,000 LF) from Silver City Ridge Lift Station to Worley Creek	$860,000
Sub-Total	***$5,920,000***
PHASE 2	
15″ sewer (14,500 LF) along Worley Creek	$2,825,000
8″ sewer (9,000 LF) along the east branch of Worley Creek	$1,190,000
18″ sewer (800 LF) from confluence of sewers to Silver City Ridge Road	$165,000
Sub-Total	***$4,180,000***
PHASE 3	
12″ sewer (15,000 LF) along creek between Frisco Road and Cemetery Road	$2,675,000
15″ sewer (15,000 LF) along creek between Richland Road and Frisco Road	$2,925,000
18″ sewer (12,400 LF) from along East Creek to Silver City Ridge Road	$2,520,000
24″ interceptor sewer (5,800 LF) from 18″ sewer to 15″ sewer	$1,365,000
24″ interceptor sewer (2,800 LF) from 15″ sewer to 12″ sewer	$660,000
27″ interceptor sewer (6,000 LF) from 12″ sewer to Worley Creek	$1,425,000
Sub-Total	***$11,570,000***
TOTAL	**$21,670,000**

Table 9-3: Estimated Costs, Alternative Sewer Development

Development	Estimated Cost
PHASE 1	
10″ sewer (12,600 LF) to Tyler Drive Lift Station	$2,035,000
Tyler Drive Lift Station	$500,000
12″ force main (10,800 LF) - Tyler Drive Lift Station to east branch Worley Creek	$1,325,000
8″ sewer (4,000 LF) along the east branch of Worley Creek (upper reach)	$530,000
15″ sewer (5,000 LF) along the east branch of Worley Creek (middle reach)	$975,000
24″ sewer (800 LF) along lower reach of Worley Creek	$190,000
Sub-Total	***$5,555,000***
PHASE 2	
8″ sewer (7,500 LF) along SH 4 to Silver City Ridge Lift Station	$990,000
Silver City Ridge Road Lift Station	$300,000
6″ force main (7,000 LF) from Silver City Ridge Lift Station to Worley Creek	$645,000
15″ sewer (14,500 LF) along Worley Creek	$2,825,000
Sub-Total	***$4,760,000***
PHASE 3	
12″ sewer (15,000 LF) along creek between Frisco Road and Cemetery Road	$2,675,000
15″ sewer (15,000 LF) along creek between Richland Road and Frisco Road	$2,925,000
18″ sewer (12,400 LF) from along East Creek to Silver City Ridge Road	$2,520,000
24″ interceptor sewer (5,800 LF) from 18″ sewer to 15″ sewer	$1,365,000
24″ interceptor sewer (2,800 LF) from 15″ sewer to 12″ sewer	$660,000
27″ interceptor sewer (6,000 LF) from 12″ sewer to Worley Creek	$1,425,000
Sub-Total	***$11,570,000***
TOTAL	**$21,885,000**

9.1.2 WASTEWATER TREATMENT FACILITY DEVELOPMENT COSTS

With regards to the costs involved in the construction of an SBR plant, bids were received in summer 2008 for the construction of the 3 MGD SBR facility at Guymon, OK. As the mechanical plant was being built from scratch, the bids included all items associated with the development of the site (access road, site fencing, site utilities, grading, building etc.) and treatment equipment (lift station, inlet works, SBR reactors, digesters, sludge handling equipment etc.). The cost of the bids for the plant (excluding converting part of a lagoon into a FEB) was $14 million, which is equivalent to $4.67/gallon treated. According to Haynes Equipment, the company that is supplying the mechanical equipment on this project, a typical construction cost for this size of SBR plant is $4-5/gallon treated. If a construction cost of $5/gallon treated is assumed, the estimated cost for a 2.45 MGD SBR plant is $12.25 million.

This is the estimated construction cost if the SBR plant were built in full in 2009 from scratch, and the cost is dependent upon how much site development is required. In reality, the SBR plant will be constructed in phases. If an initial phase (e.g. 0.5 MGD) was built from scratch, the construction cost per gallon treated would increase since the same site development costs would still be incurred for less treatment capacity; the construction cost could be $6-8/gallon treated. However, the construction cost of subsequent expansions would reduce since the site is already developed and the cost is related to construction of additional reactors and their associated equipment. In this instance, the construction cost could be $2-3/gallons treated.

Some initial site development costs mentioned above will be incurred during the construction of the initial lagoon systems (Section 8.2.2), such as site fencing and access. An estimated cost to develop an initial 5-acre lagoon system from scratch is given in Table 9-4. An estimated cost to develop an initial 15-acre lagoon system from scratch is given in Table 9-5.

Table 9-4: Estimated Cost, 5-Acre Lagoon Development

ITEM	Estimated Cost
4 no. 2.5 MG lagoons (constructed from sandy clay/loam, complete with geotextile liner, gravel along top of dikes, grass to outer slopes, and 6 ft high fencing around the lagoons. Includes contractor's overhead & profit)	$1,240,000
Interconnecting pipework, gravel access road,	$100,000
Sub-Total	***$1,340,000***
Purchase land (20 ac @ $10,000/ac)	$200,000
Engineering & Construction Overview (10%)	$134,000
Contingencies (20%)	$268,000
TOTAL	**$1,942,000**

Table 9-5: Estimated Cost, 15-Acre Lagoon Development

ITEM	Estimated Cost
2 no. 5 MG primary lagoons	$1,140,000
2 no. 7 MG secondary lagoons	$1,444,000
(Lagoons constructed from sandy clay/loam, complete with geotextile liner, gravel along top of dikes, grass to outer slopes, and 6 ft high fencing around the lagoons. Includes contractor's overhead & profit)	
Interconnecting pipework, gravel access road,	$150,000
Sub-Total	***$2,734,000***
Purchase land (20 ac @ $10,000/ac)	$200,000
Engineering & Construction Overview (10%)	$273,400
Contingencies (20%)	$546,800
TOTAL	**$3,754,200**

If a 5-acre lagoon system were initially developed and then expanded to a 15-acre lagoons system, the estimated cost of the expansion (convert the existing four lagoons into two primary lagoons and install two secondary lagoons) is $2.2 million.

Given the above costs estimates, the cost for each phase stated in Section 8.2.2 based on current prices is likely to be in the region of:

- Phase 1a ~ $2 million (Develop 5 acre lagoon system, serving 800 people)
- Phase 1b ~ $2.2 million (Expand lagoons to 15 acres, serving 1,900 people)
- Phase 1c ~ $ 4 million (Install 0.5 MGD SBR plant)

9.1.3 INITIAL DEVELOPMENT COSTS

A cost estimate has been developed to install a temporary packaged wastewater treatment unit on site at a housing development. The cost is given in and is based upon a quote provided by Pollution Control Systems, Inc.

Table 9-6: Estimated Cost, Packaged Wastewater Treatment Unit

ITEM	Estimated Cost
16,000 gpd treatment unit (Model # PP-16-ESC), delivered in one piece	$124,000
Delivery to site and installation onto a prepared concrete slab	$76,000
Lift station (oversized manhole)	$50,000
Treated Wastewater Well (steel tank sitting on concrete slab)	$50,000
Miscellaneous (fencing around unit & tank, treated wastewater well pump, controls etc.)	$50,000
TOTAL	**$350,000**

If two packaged treatment units were to be installed at one location at once, the estimated cost is $600,000. The costs do not include the cost of a tanker truck that would be required to transport the treated wastewater from the unit to the holding lagoon prior to land application.

The cost to develop a 5-acre lagoon system, to first hold the treated wastewater from the packaged treatment unit and then to treat sewer flows when the conveyance system is complete, is given in Table 9-4. A land application system is also required, and a typical cost of a center pivot irrigation system that can irrigate 160 acres is approximately $150,000. The estimated cost of the combined lagoon and land application system is therefore $ 2.1 million. This cost assumes that no additional irrigation land is required to be purchased by the City and that an agreement is reached with a landowner to irrigate his land.

9.2 FUNDING OPTIONS

There are several basic options available to any city to generate revenue to pay for infrastructure improvements. Funding is usually obtained through bonds or loans that are then paid off using the generated revenue. The revenue options include one or a combination of the following:

- Utility rates
- Ad valorem tax
- Fees
- Grants

The following is a general overview of the different revenue options.

9.2.1 UTILITY RATES

As of September 2009, the City had 640 customers (570 residential, 25 non-profit and 45 commercial) connected to the sewer system and paying sewer rates. The sewer rates were last increased in July 2009 (Table 9-7) and generated revenues are currently in the region of $8,200 per month, or $ 98,400 per year. For residential customers, revenue is currently in the region of $155 per customer per year.

Table 9-7: Tuttle Public Works Authority Sewer Fee Schedule

Sewer Rates - Residential	**Fee Schedule**
First 5,000 gallons of water consumed	$10.50
Next 15,000 gallons of water consumed	$2.10
Above 20,000 gallons of water consumed	$1.05
When not connected to TPWA water system	$10.50
Customers outside of city limits	120% of in-city rates
Sewer Rates – Non-Residential	
First 20,000 gallons of water consumed	$16.80
Each additional 10,000 gallons of water consumed	$8.40
When not connected to TPWA water system	$31.50
Customers outside of city limits	120% of in-city rates
Other Sewer Fees	
Residential taps	$750.00
Commercial taps	$750.00
New service initiation when not served by TPWA water system	$400.00

Currently the City are using revenue generated from sewer rates to help pay for the recent improvements to the water treatment and distribution system. Given the small sewer customer base and the committed use of revenue elsewhere, there is currently little prospect of providing initial funding for wastewater capital projects from sewer rates; however as new customers connect to the new sewer system, increased revenues from sewer rates would help to pay off any debt incurred in funding capital projects.

One way to increase revenue from sewer rates would be to increase the rates. From the sewer rates stated in Table 9-7, the maximum monthly sewer charge for residential City customers (those consuming more than 20,000 gallons) is $13.65 per month. A comparison can be made between the City's sewer charges with the sewer charges of other cities to determine whether the rates can be considered low, with the potential to be raised without being excessive, or high. Table 9-8 compares the City's sewer charges against those charged by five other Oklahoma cities of various sizes.

With the exception of Newcastle, this table shows that the City's sewer charges are less than the other cities for water consumption demands of 3,000 gallons or more. Due to their rate structure, Oklahoma City, Edmond and Norman have lower charges for demands of less than 3,000 gallons. A typical household consumes about 5,000 gallons of water per month; therefore the average Tuttle citizen is paying less in sewer charges when compared to the other cities. A potential reason for this is probably due to the fact that the City only has lagoons as the wastewater treatment system, whereas the other cities have mechanical plants that incur greater operational and maintenance costs.

The table does show that the City could increase sewer rates for high water consumption users and still have a comparatively low sewer rate structure; however given the relatively small sewer customer base, increasing sewer rates isn't going to generate much additional revenue until the customer base is increased.

The City has a much larger water customer base (currently 1,447) than sewer customer base, so another funding possibility would be to increase water rates and use the additional generated revenues. The current City water rate structure is as follows:

- $12.12 for the first 2,000 gallons
- $6.11 per 1,000 gallons for the next 5,000 gallons
- $6.16 per 1,000 gallons for all usage above 7,000 gallons

Table 9-9 compares the City's water charges against those charged by the same five cities per month.

This table shows that the City's water charges are more than the other cities at both low and high water consumption values, with the exception that Newcastle is more expensive at low consumption values. A potential reason of this is that the other cities are larger than Tuttle and so have the advantage of economies of scale. As water charges are high in comparison, raising water rates further may be considered excessive and would prove to be unpopular. As the customer base expands with the expanding City population, the relative cost to supply water will decrease as some economies of scale are realized, and if water rates remained relatively high, excess income could be used to help pay off any debt incurred in funding capital wastewater projects. The City could increase revenues from the water system by not allowing private water wells for yard watering, thus increasing potable water consumption.

Table 9-8: Comparison of Sewer Charges

Water Consumption Per month (gallons)	Oklahoma City	Edmond	Norman	Tuttle	Newcastle	Shawnee
3,000	$11.34	$10.75	$11.70	$10.50	$9.50	$15.45
5,000	$17.82	$13.75	$19.50	$10.50	$9.50	$20.95
10,000	$34.02	$21.25	$39.00	$12.10	$9.50	$34.70
20,000	$66.42	$36.25	$78.00	$12.10	$9.50	$62.20

Table 9-9: Comparison of Water Charges

Water Consumption Per month (gallons)	Oklahoma City	Edmond	Norman	Tuttle	Newcastle	Shawnee
3,000	$13.82	$12.07	$10.00	$18.23	$26.07	$14.68
5,000	$18.12	$20.37	$14.00	$30.45	$35.11	$22.26
10,000	$28.87	$41.12	$24.50	$61.15	$57.71	$41.21
20,000	$50.37	$88.02	$38.75	$122.75	$102.91	$79.11

9.2.2 *AD VALOREM TAXES*

In using sewer rates to fund capital projects, the burden of paying for a new wastewater system would fall on the sewer customers (both existing and new) only and not the whole community. Initially only new sewer customers would directly benefit from the new infrastructure until such time that the existing sewer system was connected into the new sewer system. To increase the funding base to include the whole community, one potential option would be to impose an ad valorem tax (sales tax or property tax) rate dedicated to the funding of the wastewater system. One of the reasons for the installation of a new wastewater system is to encourage commercial growth along the SH 4 corridor, which would a benefit to the City. While commercial development itself will not generate significant revenue from sewer rates, an increase in sales tax revenues would help to fund future expansion of the treatment system.

The citizens of Tuttle may not vote to raise ad valorem taxes to pay for a new wastewater system if it is perceived that the only people who benefit from it are new residents and not existing residents on septic tanks.

9.2.3 *FEES*

As an alternative to ad valorem taxes, one way for the City to generate revenue from the whole community would be to charge a fee to existing lots not paying sewer rates, on the basis that a new wastewater system would indirectly benefit the whole community (e.g. increased sales tax revenues from commercial development, leading to new or improved public services) and not just directly benefit those connected to the system.

One way to help overcome resistance from the community to an ad valorem tax or a fee on non-sewered lots would be to pass some of the burden of financing a new wastewater system to new customers, who would have a direct benefit from the system. This can be achieved by charging an impact fee on new lots to help pay for the portion of the costs that a new development may cause the City in providing a collector sewer to that development. The fee is usually applied at the time a building permit is issued and is dedicated to the provision of additional services. The fee cannot be used to pay for operation or maintenance of a service, and it must also be linked to the cost of providing the service (i.e. not an arbitrary amount).

The City could set up a fund into which all of the impact fees (plus any revenue generated from an ad valorem tax or septic tank lot fee) are deposited. The City would temporarily treat sewage from new developments using one of the options discussed in Section 8.3 until such time that funds were available to finance the construction of each section of the new wastewater system that would allow the developments to connect to the system. A section would be built when there was sufficient money in the fund to finance its construction, and the fund would be drawn down. The fund would then have to be replenished before the next section could be built.

9.2.4 *GRANTS*

Grants are also available to help fund wastewater infrastructure projects. Community Development Block Grants (CDBG) are available from the Oklahoma Department of Commerce (ODOC) to fund the engineering design and construction of wastewater projects. The maximum grant available for construction is $350,000. Additional grants are also available from ODOC through the Rural Economic Action Plan (REAP) program, where funding obtained through CDBG is matched. In order to obtain funding, a community must show that the project achieves at least one of the following three objectives:

- Provide benefit to people earning low to moderate incomes
- Aid in the prevention or elimination of slums or blight
- Meet other community development needs having a particular urgency, or posing a serious or immediate threat to the health or welfare of the community.

9.2.5 SOURCES OF CAPITAL - BOND ISSUE/LOANS

The City could have a bond issue as means of obtaining capital, which is typically paid off over a 30-year period. According to City staff, a realistic bond capacity for the City is currently $4 million, which would only pay for part of the initial system development.

The City could also obtain loans to help finance capital projects, but currently is paying off some existing loans, namely:

- $4 million for the new water treatment plant
- $ 700,000 for fire trucks
- $150,000 for police cars

One potential source of loans to the City is the Clean Water State Revolving Fund (CWSRF), which is administered by the Oklahoma Water Resources Board (OWRB). The CWSRF is a low-interest loan program designed to assist communities in funding wastewater and other pollution control projects. In order to obtain funding, the project must be listed on the CWSRF Project Priority list and current Intended Use Plan maintained by the OWRB. The loan terms include a 0.5% administration fee and a 20-year maximum payback period, with interest and administration fees billed every 6 months. The interest rate is typically 40% below market rate.

9.2.6 SUMMARY

From this general overview, it would appear that there is no one funding option that could finance the construction of a new wastewater system alone; a combination of funding sources are likely to be required. Revenues from sewer rates will increase as new customers connect to the wastewater system, but current revenue is too small and is allotted to paying off other debts to fund capital projects. The best course of action for the City would be to undertake a detailed financial analysis in conjunction with a financial advisor and a consultant to be creative and determine which combination of funding sources could be employed to pay for the initial development and subsequent expansions of the wastewater system.

10 SUMMARY

The following section is a brief, bullet point summary of the findings of this report.

Existing General Community Conditions

- The City is largely an agricultural community on the south bank of the Canadian River with a focus on wheat, cotton, hay and cattle.
- Due to the construction of a new bridge over the Canadian River in 2001 that extended SH 4 south to I-44, growth has concentrated in the area of the intersection of SH 4 & SH 37
- The City encompasses an area of 29.2 square miles, and the population was 4,294 at the 2000 United States Census. According to City records, the population reached 6,000 in July 2009.
- Most of the land north of Silver City Ridge Road is located within the Canadian River floodplain.
- The 2020 master plan calls for the City to develop east of Cemetery Road, with the land use west of this road to remain agricultural land.
- Old Tuttle is connected to a lagoon system that is operating at 50-60% of design capacity; new developments outside this area are connected to septic tanks.

Growth and Sewer Flow Projections

- The ODC/Census Bureau model predicted that the population of Tuttle would increase from 4,294 in the year 2000 to 5,220 by the year 2030. This population has already been surpassed.
- The drivers for growth in the City include improved access to Tuttle due to the completion of the SH 4 bridge, coupled with a desire to live in a rural setting relatively close to a metropolitan area.
- Tuttle currently has a population density of 200 people per square mile. A future population density of 1500 people per square mile would preserve the open feel of Tuttle while also providing the advantages of a medium sized municipality.
- Using the 1500 people per square mile population density, the ultimate 'build-out' population of Tuttle would be 33,750, based upon the available land outside of the floodplain.
- It is estimated that the population connected to a sewer system at ultimate 'build-out' would be 24,500. This could be increased if further use of septic tanks is prohibited.
- The ultimate connected population would lead to an average daily design flow of 2.45 MGD.

Evaluation of Treatment Plant Alternatives

- Discharge of treated wastewater to the Canadian River and the likely consent standard are dependent upon the outcome of the WLAS.
- A permit based upon seasonal discharge to the Canadian River is possible; land application or evaporation would be required for the summer months.
- Treatment technologies acceptable to ODEQ include lagoons, RBC and any activated-sludge process (including SBR, MBR and oxidation ditches).

- Lagoons would require too much land for the ultimate population, and the City has expressed a preference for a mechanical plant. Lagoons could be used as an interim measure (either evaporation or flow-through with land application).
- RBC plants are currently being removed from several wastewater treatment plants in Oklahoma due to operational problems.
- High-level evaluation suggests SBR would be the most appropriate activated sludge technology, and it is extensively used throughout Oklahoma.

Facility Location/Site Selection

- The lower reaches of Worley Creek outside of the floodplain should be considered the primary area for the City to locate a wastewater treatment facility, with the lower reaches of East Creek above the floodplain considered the secondary location area.
- The results of a search of state and federal environmental databases revealed that there are no documented environmental concerns that could have a major impact on the selection of a facility site in these two areas.

Conceptual Plan

- The long-term development of a sewer system should be split into three broad phases.
- Phases 1 and 2 would provide the trunk sewers to serve development areas identified in the 2020 Tuttle Comprehensive Plan. Commercial development areas would be served first followed by residential development areas. Phase 3 would be to serve the rest of the City.
- Trunk sewers would be laid along creek valleys to take advantage of gravity flow. An interceptor sewer would be laid east-west along the edge of the floodplain to transport the sewage to the treatment plant.
- A minimum of 20 acres is required for the construction of a wastewater treatment plant.
- Initial treatment could consist of lagoons that could be reused to perform another function when a mechanical plant is built.
- A mechanical plant would be expanded incrementally as dictated by actual population growth.
- Some form of temporary treatment would allow the City to treat sewage and obtain revenue from new customers until such time that they can be served by the new wastewater system.
- Portable, packaged temporary treatment unit(s) could be installed to serve new development(s), with the treated wastewater discharged to the lagoon outfall by tanker truck. After the trunk sewer is laid to a development, the unit could then be moved to another development.
- Treated effluent from temporary treatment unit(s) could be discharged via tanker truck to a holding lagoon constructed at the wastewater treatment plant for land application. The lagoon would then be turned into a flow-though treatment lagoon when the first customers are connected to the sewer system.
- Low-cost tanks could be temporarily installed at a new development to store and aerate sewer flows. The aerated sewage would then be discharged to the existing lagoons by tanker truck for treatment, since the lagoons have spare capacity.

- The Phase 1 sewer could terminate at a lift station at the plant site and a temporary force main installed to the existing lagoons. The lift station and main would then be reused to perform another function when a mechanical plant is built.

Preliminary Financial Analysis

- High-level cost estimates have been developed that include the cost of engineering design and 20% contingencies, based on construction cost estimating manuals.
- The high-level cost estimate to install all three phases of sewer development is approximately $21.7 million; the cost estimate for Phase 1 is $5.9 million.
- The high-level cost estimate to construct a complete wastewater treatment plant from scratch to treat the ultimate average daily flow is $4-5 per gallon treated.
- The high-level cost estimate to develop an initial 5-acre lagoons system to serve 800 people is approximately $2 million.
- The high-level cost estimate to develop an initial 15-acre lagoon system to serve 1,900 people is approximately $3.75 million.
- The high-level cost estimate to purchase and install a temporary treatment unit to serve 160 people is approximately $350,000. This is based upon an actual manufacturer's budget quote.
- The existing revenues generated from sewer rates are too small to finance capital projects, and additionally is currently being used to help pay for the recent water system improvements.
- Sewer rates could be increased, but this wouldn't generate much additional revenue. Water rates are high and should not be increased further.
- Alternative funding options include an ad valorem tax, impact fees, septic tank lot fee and grants.
- A realistic bond capacity for the City is $4 million.
- The City is currently paying off loans to the value of almost $5 million.

11 CONCLUSIONS AND RECOMMENDATIONS

Tuttle has experienced rapid growth in recent years that has outstripped existing population projects. The growth has occurred in the eastern part of the City in response to the building of a bridge over the Canadian River on SH 4. Residential development has occurred on lots large enough to permit the installation of individual on-site wastewater treatment systems. The result of large residential lots is that there is relatively low population density within these areas, which leads to a feeling of "openness" to the areas.

The City has three distinct choices as to how Tuttle will develop in the future, which will affect how the City's decided to proceed in the installation of a wastewater collection and treatment system:

1. Residential development is restricted to low or no growth levels to maintain the rural feel of the City. A wastewater system would not be required.

2. Large residential lot development is allowed or encouraged to continue as present, which would mean the continuation of low density housing with individual on-site treatment systems. If this pattern of growth is maintained, then it is likely that there would not be a critical mass of population to connect to and fund the system.

3. Denser but still relatively open ½ to 1 acre residential lot development is encouraged to achieve a viable population that can connect to a wastewater treatment system and generate adequate revenue to fund the expansion, operation and maintenance of the system.

Denser residential development is required for the City to have a viable wastewater system. If the City wants to allow residential development to continue and have such a system, it is recommended that the City should aim to achieve an average population density of 1500 people per square mile. At such a population density, the City should not feel "crowded" and some of the feeling of "openness" should be maintained. Different parts of the City could have different population densities; currently Old Tuttle has the highest population density and the eastern part of the City has the lowest population density, therefore it makes sense to maintain this population density gradient across the City. At this density Tuttle will become large enough to attract and sustain commercial and municipal amenities such as retail shops, restaurants, recreation facilities, professional services, additional schools, health care, etc.

Before a decision is taken by the City to invest in a wastewater system, it is recommended that the City undertakes a detailed financial analysis to determine how the implementation of the system can be funded based upon the estimated costs indicated within this study. Current revenue generated from existing wastewater system customers is being used to pay for recent water system improvements. Financing must be obtained from other sources, such as ad valorem tax, impact fees, septic sewer lot fees or grants, and the sewer rates revenue generated from new customers connecting to the new wastewater system.

If a decision is taken that a wastewater treatment system is desirable for the City and should be installed, it is recommended that the initial phase of the wastewater collection system should be installed to serve the SH 4/SH 37 corridors (Phase 1). These areas have been identified by the City as commercial development areas, and the installation of a sewer system would encourage development. Although commercial customers connected to the system are unlikely to generate much revenue from sewer rates, the revenue generated from sales tax would help fund the system's installation. In addition Phase 1 would also serve an estimated residential population of 4,000.

With the initial development area identified, the first major decision the City faces in developing a wastewater system is where to locate a wastewater treatment facility, to serve not only the initial collection system development but subsequent expansions. It is recommended that the City locate the facility in the lower reaches of either Worley Creek or East Creek and on the edge of the floodplain. It is also recommended that the City purchase a minimum of 20 acres, although purchasing more land (e.g. 40 acres) would be preferable if it was available. It is recommended that the City undertake further study to identify and assess all suitable individual sites within the recommended area prior to the purchase of the land. Site selection and land purchase should be considered a priority by the City in the development of a wastewater system.

Until the WLAS is completed by ACOG, a determination of what discharge standard will be imposed for discharge to the South Canadian River cannot be made. Since a determination is unlikely to occur until 2011, it is recommended that the City commences development of a treatment facility that does not require a discharge to the Canadian River as an interim measure; this measure would then be incorporated into the final facility design. The interim measure could be total retention lagoons, or flow-through lagoons with disposal of treated wastewater through land application, or force main connection from the future plant site to the existing POTW, which has spare capacity. If land is available to the City for land application, or if the City reaches an agreement with Braum's/other land owners to supply them with treated wastewater for their land application use, then it is recommended that the City install flow-through lagoons as the interim measure, as they can treat a higher flow rate within the same lagoon size compared to total retention lagoons.

With the installation of an interim treatment facility, the City does not need to make any quick decision as to the treatment technology to be selected for the mechanical plant. It is recommended that no decision is made until after the determination of the discharge standard to the Canadian River has been made. During this period it is recommended that City public works staff familiarize themselves with the treatment technologies discussed in this study (especially SBR) so that they are informed as to respective merits of each technology and can actively engage in the selection process. It is recommended that further engineering evaluation is undertaken into the main treatment technologies to better define their capital, operational and maintenance costs and other tangible and non-tangible factors to help the City in the selection process to select the most appropriate technology with the lowest whole-life cost.

The estimated cost for the City to fully develop a complete Phase 1 wastewater system is $5.9m. From the financial information available for this study, it appears that completing this phase as a complete package would be a financial burden on the City, and will have to be constructed in stages. During this period, opportunities for commercial or dense residential developments will be restricted by the lack of a treatment system. In addition, the City would not gain benefit from the system in terms of revenues from sewer rates and sales tax until both the collection and treatment systems were in place. One way to overcome these obstacles would be for the City to provide temporary treatment to a development site while the initial system was being installed.

This temporary treatment would allow the City to obtain new revenue from sewer rates and sales tax that could be used to help fund the initial system installation. The treated wastewater produced by the temporary treatment would need to be disposed of, either to the existing POTW or via land application.

In summary, it is recommended that should the City decide to proceed with the installation of a wastewater treatment system that the priority items for the City are to purchase the land where the permanent treatment facility is to be located, and to provide a sewer and temporary treatment to the commercial area at the SH 4/SH 37 intersection. Purchase of the land would ensure that the ideal location for a treatment facility is available when funding becomes available for its construction. Providing temporary treatment would allow commercial development to commence. It is recommended that treated effluent from the temporary treatment is discharged to the POTW using tanker trucks to transport the effluent. The estimated cost to carry out these recommendations is $1.6m, the breakdown of which is given in Table 11-1.

Table 11-1: Recommendations Cost Estimate

Recommendation	Estimated Cost	Notes
Purchase land for treatment facility	$400,000	40 acres at $10,000 per acre
Install sewer to commercial area	$700,000	1 mile of 8-inch diameter sewer
Temporary treatment	$350,000	From Table 9-6
Tanker trucks	$150,000	Estimate for 2 trucks
Total Cost Estimate	**$1,600,000**	

An alternative to temporary treatment and tankering of treated effluent would be to connect the sewer in the commercial area to a lift station and pump sewage to the POTW for treatment. This would involve the construction of a 6-inch diameter forcemain of approximately 6.5 miles long. This would eliminate the ongoing operational and maintenance costs associated with the tanker trucks; the pumps at the lift station would incur some operational and maintenance costs, but they would be much reduced. However the estimated cost to install a lift station and forcemain is $3.2m; therefore this alternative is not recommended.

APPENDIX A – MEETING NOTES

APPENDIX B – ENVIRONMENTAL REPORT

APPENDIX C – SBR PLANT INFORMATION