RAYMORE WASTEWATER
MASTER PLAN UPDATE

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ENGINEERS & ARCHITECTS

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EXECUTIVE SUMMARY

Wilson & Company was tasked with updating the two areas of the 2004 Wastewater Master Plan. Those areas included an area called Alexander Creek drainage basin and the Southeastern expansion areas. These areas are shown on Figure 1.1 of the report as Area B and Area D.

The purpose of the Master Plan Update was to address the proposed Middle Big Creek Sewer Expansion Project, the proposed Hollyday Farm Development, and a new school located near the Hollyday Farm Development, as well as capacity issues of the existing 18-inch diameter Alexander Creek Interceptor.

The report makes the following conclusions and recommendations:

- Alexander Creek Interceptor will need to be upsized by year 2009 if existing inflow and infiltration which cause peak flows of 13 times average flows cannot be reduced. Under this 0% decrease in inflow and infiltration only 157 additional connections can be added to the existing system. Wilson & Company recommends the City continue efforts to reduce inflow and infiltration by at least 30% and prepare to replace the existing 18-inch pipe. This work could be done in phases, with the lower reaches replaced first.

- With a 30% reduction in inflow and infiltration, sanitary sewer flows can be received into existing 18-inch Alexander Creek Interceptor from Hollyday Farms and the school until the year 2016. At that time the Interceptor will have to be expanded or a new interceptor will need to be built to the proposed Middle Big Creek Interceptor. It is recommended the existing interceptor be replaced with a 24-inch diameter pipe. The estimated cost is $5.6 Million.

- With regard to Area D, the Southern Expansion area, Wilson & Company divided the basin into three areas, eastern (Basin C), central (Basin B), and western (Basin A or Whitetail Run), see Figures 7.1-7.3. It appears that the City will need to be prepared to spend $27 Million to develop sanitary sewers in these areas to meet the population projections in the year 2040. Three options are reviewed and discussed in the report.

- The report also reviews treatment options for the Southern Expansion Area and the costs associated with the City building a Treatment Plant. Due to changes in the law concerning discharge permits, an Anti-Degradation Study and Facility Plan will need to be completed to construct a treatment plant. The present value cost of a 3 million gallon per day treatment plant is expected to be in the range of $25 Million to $37 Million depending on treatment requirements determined by an Anti-degradation Study of the discharge stream.

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to update the 2004 Wastewater Master Plan by Burns & McDonnell for the development of wastewater facilities for the City of Raymore, Missouri in the Alexander Creek watershed and southern annexation area (areas B and D, respectfully) as shown in Figure 1.1. The drivers for this update are Middle Big Creek (MBC) Sub District's proposed expansion, the Hollyday Farm development, and a new school to be located east of Raymore. The Master Plan update will assist the City in scheduling, planning, budgeting, funding, designing, and constructing improvements to the existing wastewater facilities and address growth occurring in the areas identified above. The time horizon for this report is 30 years.

As this report only updates portions of the 2004 Master Plan, this report will parallel the original reports structure, adopt many of the same assumptions, and use existing flow and modeling data from the original report. The scope of this report does not include an in depth analysis of the existing pipes or pump stations with the exception of the Alexander Creek Interceptor as these are not located in Areas B and D.

1.2 SCOPE

The scope of the Wastewater Master Plan Update includes the following:

1.2.1 TASK 1 – REVIEW AND FINALIZE THE WORK PROGRAMS AND SCHEDULE

Meet with City staff to obtain existing data and staff's ideas on the project direction and desires for a final product, conduct an analysis of the Alexander Creek Interceptor (Area B) to review current and future capacity of the Little Blue Valley Sewer District's facilities, meet with the District's staff and determine the City's costs and responsibilities related to the Middle Big Creek expansion. Meetings are also to be held with neighboring entities (such as

Belton and Peculiar) and other interested groups as the City staff see fit for treatment options for the southern areas of the City (Area C and D).

1.2.2 TASK 2 – DATA COLLECTION AND FLOW MONITORING

Data from the 2004 Wastewater Master Plan and other information (such as flow monitoring records) will be collected, reviewed and summarized as they relate to areas of concern in a written report.

1.2.3 TASK 3 – WASTEWATER CAPACITY ANALYSIS

Perform pipe capacity analysis of any proposed improvements in Areas B and D. Determine new treatment facility size based upon the capacity analysis.

1.2.4 TASK 4 – DEVELOPMENT AND ANALYSIS OF ALTERNATIVES

Utilizing City Standards for flow calculations and drainage basin maps, determine possible pipe and pump station locations needed for the different alternatives. Also, develop drawings to depict acreage, proposed population density and resulting wastewater flows utilizing data collected in Task 1 and Task 2. All future development will be for the proposed time frame of 30 years. Project phasing will be reviewed to estimate when and where improvements will be required.

1.2.5 TASK 5 – REVIEW FINDINGS & RECOMMENDATIONS W/ STAFF

Review findings with City staff, develop proposed alternatives, and present worth cost analysis incorporating staff comments into the final report.

1.2.6 TASK 6 – CONDUCT WORKSHOP W/ CITY COUNCIL

Conduct a workshop with the City Council and present the findings of the report previously approved by City staff.

1.2.7 TASK 7 – DEVELOP AND ANALYSIS OF FINANCING

Meet with the City's independent financial advisor to discuss the recommendations, costs, and proposed funding options as well as selected rate options to be incorporated into the Sewer Rate Model.

1.2.8 TASK 8 – MASTER PLAN UPDATE REPORT

A final written report utilizing comments from City Staff along with a City Council Work Session presentation will be developed and delivered to the City, completing the project.

1.3 ENGINEER'S OPINION OF COSTS

The opinions of probable cost provided in this report are based primarily on our recent experience and opinion as a professional consulting firm combined with information from contractors, vendors and publically available sources. As in the 2004 Master Plan, for pipeline construction costs an average bury dept of 15-feet with the last 5-feet being in rock has been assumed. Geotechnical confirmation of the subsurface conditions is beyond the scope of this report. Excavation methods vary appreciably with rock characteristics and contractor experience and consequently will have a substantial impact on final project costs. Other factors that affect cost but which cannot be controlled are availability and cost of labor, material, and equipment, construction contractor's procedures and methods, economic conditions, government regulations and laws (including the interpretation thereof), competitive bidding conditions, weather, and other factors.

Therefore, the final project construction, engineering, and legal costs will vary from the opinion of costs provided in this report, and funding needs must be reviewed based on current economic conditions prior to making detailed financial decisions or establishing final budgets. The opinion of costs for all pipelines, equipment and hardware included in the improvements and upgrades typically include materials and installation of auxiliary electrical and mechanical systems and instrumentation. Three phase power is assumed to be available at intersections as indicated on calculations sheets. Cost opinions do not include taxes, wastewater analysis or testing of any kind, special construction requirements, acquisition of easements, any hazardous materials or waste mitigation or disposal, legal expenses beyond reasonable and customary, or any other non-construction costs not explicitly stated. In paralleling the original report, an allowance of 20% has been made for ordinary legal, administrative and engineering costs and an allowance of 15% has been made for contingency.

2.0 EXISTING FACILITIES

2.1 GENERAL

This section of the report presents a summary of the existing wastewater facilities currently operated by the City of Raymore as well as an orientation to the City. The City of Raymore is located entirely within the limits of Cass County. The City is bounded on the north by Lee's Summit and unincorporated Jackson County, unincorporated Cass County to the east, the City of Peculiar to the south and the City of Belton on the west.

2.2 BACKGROUND

The City of Raymore does not currently own any wastewater treatment facilities. The City's existing wastewater system consists primarily of gravity sewers, force mains, and pump stations. Currently, the City is located in four watersheds: Alexander Creek, Whitetail Run, Owen-Good, and Lampkin's Fork. The latter watershed is the only basin not served by a pump station. The wastewater sewer system, watershed boundaries, and watercourses are shown in Figure 2.1.

The Alexander Creek interceptor service area drains flow east from the center of the city to a Little Blue Valley Sewer District pump station near Raintree Lake. (Decommissioning of this pump station is planned in the near future.) Whitetail Run is located immediately south of the Owen-Good watershed and terminates at a pump station. The Whitetail Run Pump Station pumps over the ridge to the north and discharges to the Owen-Good Pump Station. The Good Ranch watershed encompasses generally the south western portion of the city. This watershed drains to the Owen-Good Pump Station which pumps wastewater north across the watershed boundary to the Lampkin's Fork interceptor. The Lampkin's Fork watershed, located in the northwestern portion of the city, gravity drains to the Lampkin's Fork interceptor, which empties into the Little Blue Valley Sewer District.

Currently, all wastewater generated by the City of Raymore are conveyed to the Atherton Wastewater Treatment Facility operated by the Little Blue Valley Sewer District. The District operates under an agreement to accept wastewater from the City of Raymore. The City is billed quarterly by the District for the City's percentage of flow to the facility to cover operating costs and debt service of the District. Due to expansions now occurring with the Little Blue Valley Sewer District, this report will evaluate if it is in the long term interest of the City to continue convey flows from the Owen-Good Pump Station to the Little Blue Valley Sewer District's facilities.

2.2.1 COLLECTION SYSTEM

The 2004 Master Plan listed diameter and quantities of pipe in the existing sewer system. These quantities can be found on page I-2 of the 2004 Master Plan and represent the current system with the exception of the Whitetail Run service area which was constructed after the completion of the 2004 Master Plan. Quantities for the Whitetail Run portion of the collection system are:

- 410 linear feet of 21-inch pipe
- 2140 linear feet of 18-inch pipe
- 6300 linear feet of 12-inch pipe for the Whitetail Run Force Main

2.2.2 PUMP STATIONS

Raymore operates several pump stations located throughout the City. With the exception of Owen-Good and Whitetail Run Pump Stations, all the pump stations are designed to serve a specific development. The Owen-Good and Whitetail Run Pump Stations are situated at the bottom of their respective watersheds and are designed with a substantially larger capacity.

Several of these smaller pump stations, such as Hunter's Glen, will be retired when the necessary interceptor is installed. Table 2.1 provides a summary of City pump stations in the existing system.

Table 2.1 City of Raymore Pump Stations

Pump Station Name	Number of Pumps	Location
Owen-Good PS	6	195th St & Ranch Rd
Whitetail Run PS	2	203th St & HWY 71
Hunter's Glen PS	2	Oak Dr & Redwood Dr
Morningview PS	2	Mercury Way & Star Dr

3.0 DATA COLLECTION

3.1 GENERAL

For this report, collection of data was limited to existing sources of information such as previous engineering reports performed by other firms. Field data collection was not within the scope of this report.

3.2 REFERENCES

Data presented in the following studies related to population growth and flow in the existing service basins was used in developing this report.

1. Raymore Wastewater System Master Plan – Burns & McDonnell, 2004
2. Flow Monitoring – Wade & Associates, May 2003
3. Flow Monitoring – Wade & Associates, August 2003
4. Middle Big Creek Sub District: Population/Connection Projections (2008-2030) – Archer, 2008
5. Gravity Sewer Specifications – Master Plan Appendix A – Burns & McDonnell, 2004
6. Wastewater Study for City of Peculiar, Missouri – Larkin Group, 2007

The following are summaries of the reports listed above.

3.2.1 RAYMORE WASTEWATER SYSTEM MASTER PLAN

The 2004 Wastewater System Master Plan report served as the basis for expansion and improvements to the Raymore Wastewater System and was used by the author of this report as a guide. This report parallels the basic structure of the 2004 Master Plan and updates the report results based on the changes to assumptions required to account for current events.

The 2004 Master Plan did not discuss Alexander Creek in the detail or depth of this report. Discussion was limited to Inflow & Infiltration (I&I) for the Alexander Creek Basin. The 2004 Master Plan indicates a peaking factor of 13 for the basin but remaining discussion of this area only provides a suggested I&I

reduction program. Expansion of the existing system within Alexander Creek was not included within the scope of the 2004 Master Plan Report.

In addition, as a result of the proposed MBC Expansion, the 2004 Master Plan conclusion and recommendations for the expansion areas required revision. With the expansion of the MBC system, the City of Raymore has the means to reduce the number of pump stations required to serve the expansion areas.

3.2.2 FLOW MONITORING – MAY

This report was designed to identify for the City the locations of flow monitoring devices, proposed installation locations, as well as rain fall collection devices. The purpose was to identify the general location and quantity of Inflow and Infiltration (I&I) into the existing sewer system

3.2.3 FLOW MONITORING – AUGUST

As a follow-up to the "Flow Monitoring – May" Report, this report was written to provide the City with information on dry and wet weather flows. Included within this report are hydrographs of the locations monitored comparing flows from various areas and indicating how average (dry weather) and peak (wet weather) flows in one area affect average and peak flows in the downstream portions of the sewer system. This report also provides the background information used by the 2004 Master Plan to recommend locations for I&I testing and removal.

3.2.4 MIDDLE BIG CREEK STUDY

This study was conducted for the Little Blue Valley Sewer District (LBVSD) to create a plan for future development in the Middle Big Creek Basin. This study is a preliminary plan for a new gravity sewer system which connects to the Raintree Pump Station and would be built to the existing or new Wastewater Treatment Facility located in Pleasant Hill, Missouri. This proposed facility will impact the Alexander Creek drainage basin. For consistency with the LBVSD study, WCI used the existing population projections from this report to develop population projections for the Alexander Creek Basin.

3.2.5 GRAVITY SEWER SPECIFICATIONS

The Gravity Sewer Specifications served as the basis for flow capacity calculations for this report. This document provided a formula for peaking factor (based on population) that was to be used to account for typical I&I when designing a new system. This document also provided “n” factors (representing interior pipe smoothness) to be used in flow calculations and the Manning Formula (see section 4.3.2) to be used to determine pipe capacity.

3.2.6 WASTEWATER STUDY FOR CITY OF PECULIAR, MISSOURI

A copy of this study, produced for the City of Peculiar’s use, was provided to WCI by the City of Peculiar to review future development of the areas between the two cities. Area D includes two drainage basins that gravity drain south towards existing drainage basins in Peculiar, which are currently served by the City of Peculiar’s wastewater facility. The study itself provides the City of Peculiar with a road map for future improvements and areas of growth.

4.0 POPULATION PROJECTIONS AND ANALYSIS

4.1 BACKGROUND

This report section reviews the historical population growth of the City of Raymore and methodology to develop the projected future population using a 30-year future timeline. It then describes the analysis and results of the calculations performed for the wastewater system.

From population growth projections, wastewater flow of 100 gallons per person per day was used to develop the flow projections that are the basis of growth in Whitetail Run basin and Expansion Areas B & C. Alexander Creek population growth is based on information provided by the City and is calculated differently than Whitetail Run and the Expansion Areas B & C. Expansion Areas B & C are identified in Figure 7.1 - Figure 7.3.

4.2 POPULATION PROJECTIONS

Historic population trends as described below will provide a reference for future population growth. The 2004 Master Plan population projections are provided along with an analysis to show they are no longer applicable due to the downturn in housing. Future population is projected based on previous experience and current events.

4.2.1 HISTORIC POPULATION TRENDS

In 2002, the City of Raymore developed a Growth Management Plan (GMP) which projected the City's growth through the year 2015. The GMP projections were partly based on population trends reported by the U.S. Bureau of the Census. The undeveloped areas to the south of the City limits (Whitetail Run and Expansion Areas B & C from the 2004 "Raymore Wastewater System Master Plan") were identified by the GMP as probable areas for future expansion.

The City began growing rapidly in the 1970's in part due to its close proximity to the Kansas City metro area and low housing costs. The City is near a number of other rapidly growing towns and cities on both sides of the Kansas / Missouri state line. The City's proximity to HWY 71 and rapid growth of business in Johnson County, Kansas, Lee's Summit, Missouri, and South Kansas City propelled the population of Raymore. All of these communities represent potential employment within a reasonable commute. Raymore's housing market is also more affordable than many other nearby municipalities. Table 4.1 provides the historic population for the City since 1940.

Table 4.1 Population 1940-2000

1940	207
1950	238
1960	268
1970	587
1980	3,154
1990	5,592
2000	11,146

4.2.2 PREVIOUS POPULATION PROJECTIONS

According to the 2004 Wastewater Master Plan, all of the population growth observed since 1970 has been within the City limits. In recent years, growth occurred in both the existing City limits and in unincorporated areas of Cass County east and south of the city limits. These areas are unsewered and eventually will demand city services.

The 2004 Master Plan also noted a significant amount of undeveloped land within the City. In the past year, a significant slowdown has occurred in the building of new homes throughout the entire region, triggered by high gasoline costs and the mortgage lending agency crisis. These economic issues have decreased new housing starts in Raymore and elsewhere in the Kansas City Metro Area.

A model of population growth was developed for the 2004 Wastewater Master Plan with input from City Staff prior to the economic downturn. The residential market, based on previous construction activity and projected construction, indicated that the City would grow at a rate of about 500 homes a year through 2030. An average occupancy of 2.76 persons per home was developed based on data from the 2000 census. In addition, a large residential development on the north side of the City, known as Creekmore, was under construction and was expected to add 150 homes per year over the next 10 years to the City. Based on these numbers, Table 4.2 was developed in the 2004 Master Plan.

Table 4.2 2004 Population Projection for Raymore, Missouri

2000	11,146
2005	18,500
2010	27,400
2015	36,000
2020	42,900
2025	48,300
2030	55,000

The 2007 estimated population for Raymore according to City Staff was 17,688 as compared to 18,500 in the 2004 Master Plan. Therefore, revised population projections are required.

4.2.3 REVISED POPULATION PROJECTIONS

As the costs of oil began to rise, so did everything dependent on petroleum, directly and indirectly. This had the affect of putting the brakes on the economy and decreasing people's purchasing power and ability to pay off home loans. With decreased money available due to the rising cost of food and fuel and stricter lending standards, new housing construction starts dropped significantly and the current forecast is for this trend to continue for some time into the future.

A new model of population growth is therefore required and is presented in Table 4.3. For the next few years, City Staff believe a 4% growth rate is more realistic compared to the historical average of 7%. With the economy predicted to return to growth by 2010 and oil prices expected to stay high, a more aggressive growth rate of 5% can be assumed to occur into the future in the expansion areas with 4% growth continuing in the partially developed basins.

Table 4.3 2008 Population Projection for Raymore, Missouri

2000	11,146
2005	16,044
2010	19,897
2015	25,394
2020	32,409
2025	41,364
2030	52,792
2035	67,377
2040	85,992

Note: Year 2000 is from US Census data and year 2005 is estimated from year 2000 data and current population.

4.3 *ANALYSIS*

The following information describes assumptions generally used in this report and serves as an explanation of the procedure followed to complete the projected flow calculations. The scope of this report did not include analysis of the existing service areas Lampkin's Fork and Owen-Good. Analysis of Alexander Creek is based on the number of connections to the sewer and not population due to the assumptions used by the Middle Big Creek Sub District report.

For the Alexander Creek drainage basin, capacities are calculated using full pipe flow. Pipe slopes from as-built plans and known invert elevations for the Alexander Creek Interceptor were used to determine flow.

For Whitetail Run and Expansion Areas B & C, pipe slopes were assumed to be 0.02% where there is no existing interceptor resulting in a conservative calculation. From this slope, the pipe size required to convey the projected flow can be calculated.

4.3.1 ASSUMPTIONS

The following assumptions were made for all calculations:

- Wastewater flow is assumed to be 100 gal per capita
- Growth is linear where previously defined
- Growth is geometric where not defined
- Raymore Gravity Sewer Specifications – Peak Flow Factor is determined from Equation 4.1

Equation 4.1 Peak Flow Factor

$$\text{Peak Flow Factor} = \frac{18 + \sqrt{Population/1000}}{4 + \sqrt{Population/1000}}$$

4.3.2 CALCULATIONS

In this report, pipe flow was calculated using slope, pipe material, pipe size and applying the Manning Formula.

Equation 4.2 Manning's Formula

$Q = A\ ((1.486)/n)\ (R^{2/3})\ (S^{1/2})$ where:

Q = Discharge in cubic feet per second

A = Cross section area of flow in square feet

n = Roughness coefficient of 0.010 – 0.013 per material

R = Hydraulic radius (R = A/P) in feet

S = Slope in feet per foot

P = Wetted perimeter in feet

All "n" values reflect the City of Raymore document "Gravity Sewer Specifications" unless otherwise indicated.

5.0 ALEXANDER CREEK

5.1 BACKGROUND

The Alexander Creek Basin is located in the northeast portion of the City of Raymore. This basin currently flows to the northeast, away from the city center, to the vicinity Raintree Lake. The Alexander Creek Interceptor (ACI) terminates when it discharges to the MBC's Raintree Pump Station, which eventually conveys the flow to the Little Blue Valley Sewer District. The basin is shown in Figure 2.1. Currently, this interceptor is approaching capacity. The scope of this report included analysis of the Alexander Creek interceptor capacity, flow projections, and timeline for required capitol improvements.

5.2 POPULATION / FLOW PROJECTION

Peak I&I information from the 2004 Master Plan, which indicated a peaking factor of 13, was used for peak flow calculations due to the significant amount of inflow and infiltration (I&I) in the Alexander Creek Interceptor. The City is working to reduce I&I with an active rehabilitation program. This report assumes the current I&I reduction project will be successful in reducing I&I by at least 30% but includes calculations assuming 0% reduction I&I and normal design using the peak flow factor and no I&I for comparison. All future growth projections assume no further growth in the existing I&I problem in any of the drainage basins.

The cornerstone of the population projections for the Alexander Creek Basin was information provided by the City in the document Middle Big Creek (MBC) Sub District: Population/Connection Projections (2008-2030). See Appendix A. To ensure consistency with the work being done on the MBC sanitary sewer design, the calculations included in this report are based upon number of connections instead of population, which prevents duplication of effort.

5.2.1 ASSUMPTIONS

For this report, it is assumed that 90% of the land in the Alexander Creek basin will be developed. Undeveloped land is land unsuitable for construction such as flood plains or storm water detention areas.

Where population projections in the referenced studies did not have a sufficient time horizon, a 4% growth rate in the number of connections in the basin was assumed after existing projections ended. All flows were assumed to come from growth inside the Alexander Creek watershed.

Please note that this analysis does not consider any capacity problems that might be present in areas upstream of manhole AC79. Manhole AC79 is located just east of J Highway and is where the Alexander Creek interceptor splits into two lines to service two sub-basins in area E, which was exclude from this report. For the purposes of this report, a flow of 6.55 gpd/in*ft was assumed from existing area E during wet weather. This flow data was derived from "Flow Data Analysis and Results" from the 2004 Wastewater Master Plan.

The following is a summary of assumptions made for Alexander Creek Interceptor calculations in accordance with the MBC study:

- Only 90% of the land in the Alexander Creek Basin is assumed to be developable.
- Population and Connections represent actual and/or projected on January 1 of designated year and are based on MBC Study Information.
- Population is defined as 2.6 people per connection.
- Growth in the Alexander Creek Basin is assumed to be 4% per year beyond 2018, the extent of the MBC study for this basin.
- Wastewater flow is 100 gallons per capita per day
- Developed acres assume ten people per acre maximum.

5.2.2 CALCULATIONS

The two main considerations when designing sanitary sewer interceptors are alignment and capacity. WCI assumed an alignment parallel to the existing alignment for simplicity. The primary factors that influence capacity of a particular pipe of a given diameter are pipe slope and pipe roughness. WCI has assumed the new Alexander Creek interceptor needed to handle future growth will be at the same slope as the existing interceptor and pipe roughness is based on existing Raymore design standards. Actual design may change the pipe location from those shown. Our analysis was based on a preference for PVC due to cost and corrosion resistance in smaller diameter pipe with RCP being used for larger pipe diameter.

According to the 2004 Raymore Wastewater Master Plan, the ACI line is subject to excessive inflow and infiltration (I&I) from runoff, rainfall events, and ground water. These extraneous flows entering the pipe significantly reduce the capacity of the system thereby limiting or preventing the City from adding additional new connections to the interceptor.

Two sets of calculations were developed to allow City Staff to examine future Alexander Creek basin growth and future pipe diameter needed from the resulting growth. The first set of calculations project the expected flow required at ultimate build-out for each I&I scenario. The second set of calculations establish the required pipe diameter of the new interceptor for each I&I scenario. The City Staff requested the future pipe diameter be sized to carry the full flow at full build-out of the basin based upon the assumptions listed above. No provision was made for parallel interceptors.

The scenarios also consider additional flow from a proposed new school and a new subdivision titled Hollyday Farms, which are not situated in the Alexander Creek drainage basin but may pump to the ACI.

Standard design criteria required by the City of Raymore and the Missouri Department of Natural Resources (MDNR) use a peak flow factor to determine appropriate pipe diameter. This peak flow factor accounts for peak hourly flows and normal infiltration.

For the purposes of this report, calculations listed as “Typical I&I” or “Peak Flow”, assume only infiltration as indicated by the Equation 4.1 multiplied by the number of connections and the average flow per connection. This calculation is used only as a baseline for what the pipe should handle and is calculated by multiplying average daily flow by the peaking factor which is derived from Equation 4.1. “30% I&I Reduction” calculations are based on the flow monitoring report referenced above, which lists a peaking factor of 13, and assume that I&I flow in existing sewered areas is reduced from the 2004 levels by 30% and that all new connections experience only typical infiltration attributed by the peaking factor. “0% I&I Reduction” calculations are based on the flow monitoring report referenced above and assume that no efforts are made to control existing I&I and all new connections experience only typical infiltration attributed by the peaking factor. According to the 2004 Master Plan, the peaking factor for ACI is 13.

5.3 RESULTS

The first calculation developed for this area is the current capacity of the Alexander Creek Interceptor (ACI). This is necessary in the evaluation below to determine when the current interceptor will exceed capacity. Using as-built drawings, the slope of each segment of pipe was calculated. From this information, the capacity of the existing line was determined using Equation 4.2.

The existing ACI pipe diameter is 18-inches from AC79 east to the Raintree Pump Station. The minimum pipe slope is 0.15%, which results in a maximum flow capacity of 5.23 cubic feet per second (cfs) as shown in Table 5.1, From the existing pipe slope information, a set of calculation tables was developed as follows. Flows were developed based on projected populations using sewer connection numbers from the Middle Big Creek Study and applying the peaking factor formula from Equation 4.1. This calculation does not include inflow and only normal infiltration. It is not possible to achieve this flow level because it assumes a 100% reduction of existing I&I that from our experience is not achievable. This calculation is the typical industry design standard for sizing new pipe diameters. This scenario is included for the purpose of comparison as it represents the base line or design standard for new sewers. A second calculation table was then developed using measured flows from the 2004 Wastewater Master Plan with a more realistic 30% I&I reduction as a starting point and connection numbers from the Middle Big Creek Study as growth for future flows. A third calculation table was then developed using measured flows from the 2004 Wastewater Master Plan with a 0% I&I reduction as a starting point and connection numbers from the Middle Big Creek Study as growth for future flows.

Finally, a set of calculations (Peak Flow, 30% excess I&I reduction, and 0% excess I&I reduction) were developed to determine the required pipe diameters of the Alexander Creek Interceptor at ultimate development.

5.3.1 RESULTS WITH PEAK FLOW

Assuming typical operating conditions, which is normal peak flow design (as required by MDNR and the City of Raymore's design regulations) and removal of all existing excess I&I, the existing 18-inch Alexander Creek Interceptor can support a total of 4,504 connections (or an additional 3,218 connections) before it exceeds capacity as indicated in Table 5.2. This report defines excess I&I as flows with a peaking factor larger than that indicated by Equation 4.1, which are normally in the range of 2.5 to 4.

Based on the populations projected as explained above and the resulting flows, the interceptor can service the proposed school and Hollyday Farms until the year 2029. Redirection of the proposed school and Hollyday Farms into an interceptor in their native basin (a sub-basin of the Middle Big Creek Basin) in the year 2029 will keep the Alexander Creek Interceptor at less than its design capacity until the year 2035.

Based on this Peak Flow design scenario and complete build-out flow projections for the ACI basin, a new interceptor line was sized from the Raintree Lake Pump Station upstream to J Highway, where ACI splits into two sub-basins. The calculation results are as indicated Table 5.3. Figure 5.1 illustrates Table 5.3 visually showing the pipe diameters needed and the location that pipe diameters would need to change in order to support full basin build-out of the ACI drainage basin with removal of all existing excess I&I.

5.3.2 RESULTS WITH 30% I&I REDUCTION

Assuming a 30% reduction in existing I&I and a standard peaking factor for all future construction, the existing 18-inch diameter Alexander Creek Interceptor can support a total of 2,737 connections before it exceeds capacity as indicated in Table 5.4. Based on the populations as projected above and the resulting flows, the interceptor can service the proposed school and Hollyday Farms until the year 2015. Redirection of the proposed school and Hollyday Farms into an interceptor in their native basin (a sub-basin of the Middle Big Creek Basin) in the year 2015 will keep the Alexander Creek Interceptor at less than its design capacity until year 2022. (See Table 5.6)

Based on this 30% reduction scenario and complete build-out flow projections for the ACI basin, a new interceptor line was sized from the Raintree Lake Pump Station upstream to J Highway, where ACI splits into two sub-basins. The calculation results are as indicated Table 5.5. Figure 5.2 illustrates Table 5.5 visually showing the pipe diameters needed and the location that pipe diameters would need to change in order to support full build-out of the ACI drainage basin with removal of 30% of existing I&I.

5.3.3 RESULTS WITH 0% I&I REDUCTION

Assuming a 0% reduction in existing I&I and a standard peaking factor for all future construction, the existing 18-inch diameter Alexander Creek Interceptor can support a total of 1,643 connections before it exceeds capacity as indicated in Table 5.6. Based on the populations as projected and the resulting flows, the interceptor can not service the proposed school or Hollyday Farms without increasing the pipe line size. The existing pipe would exceed design capacity during storm events in the year 2009. (See Table 5.3)

Based on this 0% reduction scenario and complete build-out flow projections for the ACI basin, a new interceptor line was sized from the Raintree Lake Pump Station upstream to J Highway, where ACI splits into two sub-basins. The calculation results are as indicated Table 5.7. Figure 5.3 illustrates visually Table 5.7 showing the pipe diameters needed and the location that pipe diameter would need to change in order to support full build-out of the ACI drainage basin with no reduction in existing I&I.

5.3.4 PROPOSED SCHOOL AND HOLLYDAY FARMS

The proposed school and the Hollyday Farms subdivision are located within a sub-basin of the Middle Big Creek Basin and their basin currently is not serviced by a sanitary sewer system. Inquiries have been made concerning directing sanitary sewer flow from these two proposed developments over the ridge line into the existing Alexander Creek Interceptor until a Middle Big Creek gravity sewer system is constructed.

5.3.4.1 PROPOSED SCHOOL

The proposed school is located east of the City in unincorporated Cass County and has been identified as a future annexation area. Based on the Middle Big Creek Sub District report, connection projections for the school are listed at 31 by the year 2011, with a second school addition in the year 2015 raising the total number of connections for the campus to 54. This equates to 0.05 cubic feet per second (cfs) and 0.09 cfs, respectively. An 8-inch diameter gravity sewer pipe would be required to provide sanitary sewer service at minimum slope for the proposed school.

5.3.4.2 HOLLYDAY FARMS

The proposed Hollyday Farms subdivision is located east of the City in unincorporated Cass County near the proposed school and has been identified as a future annexation area. Based on the Middle Big Creek Sub District report, the subdivision would add 86 connections per year beginning in the year 2009 and ending with a total of 860 connections in the year 2018, assuming sanitary sewer service can be provided. This equates to 0.14 cfs added per year and 1.23 cfs, in total. The flow generated from this number of connections translates to a 10-inch diameter gravity pipe constructed at minimum slope.

5.3.4.3 COMBINED FLOW FROM PROPOSED SCHOOL AND HOLLYDAY FARMS

The combined flow of the two sources above is a total of 1.32 cfs which only requires a 10-inch diameter gravity pipe, the size required to serve the Hollyday Farms subdivision alone. The school represents 7% of the final projected flow while the subdivision is projected to be 93% of the total combined flow. City staff is entertaining the idea of the Hollyday Farms Subdivision and the proposed school pumping sanitary sewer flow into the Alexander Creek Interceptor.

5.3.5 SUMMARY

Figure 5.1 – Figure 5.3 provide maps of the Alexander Creek Drainage Basin and the existing location of the Alexander Creek Interceptor which flows east toward the Little Blue Valley Sewer District Pump Station located near Raintree Lake. For the different conditions discussed above, Figure 5.1 – Figure 5.3 show the location where different pipe sizes are required based on the inflow and infiltration level expected with complete build-out of the Alexander Creek Basin.

Figure 5.4 graphically illustrates pipe capacities for 18-inch, 24-inch, 30-inch, and 36-inch diameter pipe. Crossing the lines, representing pipe capacity, are the scenarios discussed above, 0% reduction in existing excess I&I, 30% reduction in excess I&I, and normal Peak Flow or design as well as the average daily dry weather flow. These curves represent assumed flow from future growth in the Alexander Creek Drainage Basin and the connection of Hollyday Farms and the proposed school.

As can be seen in the graph, under a typical I&I design scenario where the existing 18-inch Alexander Creek Interceptor did not have excess I&I, the design capacity would not be reached until the year 2029. This would be an ideal situation and realistically is not achievable. If a 30 % reduction in existing excess I&I can be achieved and future growth would not exceed typical design Peak Flow conditions then the capacity of the existing 18-inch would not be reached until the year 2015. If no reduction in inflow and infiltration were attempted the capacity of the existing 18-inch interceptor would be exceeded in the year 2009.

Table 5.8 summarizes the number of new connections that can be added under the scenarios discussed above. The Peak Flow category requires a 100% decrease in I&I and is not obtainable but is shown for reference. Assuming the current inflow and infiltration reduction program works and reduces I&I by 30%, 1,251 connections should be able to be connected to the existing 18-inch main before capacity is exceeded.

Table 5.8 Alexander Creek Total Allowable Connections

Scenario	Proposed School	Hollyday Farms	Total Allowable Connections	Allowable Additional Connections
Future Flow Peak Flow *	Y	Y	4,504	3,018
Future Flow 30% I&I Reduction	Y	Y	2,737	1,251
Future Flow 0% I&I Reduction	N	N	1,643	157

* 100% Excess I&I Reduction

This report must also highlight that fact that the MBC stub the proposed 36-inch diameter Alexander Creed Interceptor discharges to is only a 24-inch diameter pipe. This stub would also need to be upgraded to prevent the Alexander Creek Interceptor from backing up and over flowing. Unfortunately, the 24-inch stub is located in the spillway channel for Raintree Lake thus increasing the difficulty and costs of any such upgrade. The facility plan for the MBC sub-district, while not totally complete, does not at this time foresee upgrading the stub under the spillway.

As a general rule, sewers do not convey flow to interceptors with a smaller diameter. Therefore, this report also reviewed the implications of installing a 24-inch diameter interceptor in Alexander Creek. Based on the population projections, the maximum capacity of the Alexander Creek watershed is approximately 19,000 connections. The construction of a 24-inch diameter interceptor will increase the number of connections available for use by development growth but still limits the total development of the basin as tabulated in Table 5.9.

Table 5.9 Alexander Creek 24-inch Allowable Connections

Scenario	Year Capacity Reached	Total Allowable Connections	Total Additional Connections
Future Flow Peak Flow *	2057	11,350	9,864
Future Flow 30% I&I Reduction	2050	8,845	7,359
Future Flow 0% I&I Reduction	2044	7,182	5,696

* 100% Excess I&I Reduction

Once the capacity is again reached, there are three possibilities. The first is for MBC to upgrade their interceptor connection stub to accept increased flows from Alexander Creek and the City to either install a 24-inch interceptor parallel to the suggested 24-inch interceptor or a new 36-inch interceptor for Alexander Creek. The second possibility is to limit growth to the capacity allowed by the 24-inch interceptor. The third option is to pump the excess flows over the ridge line to the south. The flows can then be conveyed down the Expansion Area C watershed to MBC's proposed interceptor and eventually to the proposed MBC treatment facility at Pleasant Hill. This alternative is represented graphically in Figure 5.5.

The calculations presented are based upon the design assumptions listed above. Growth conditions can change extending or decreasing the times frames discussed above.

5.4 COSTS

Due to the presence of existing service in Alexander Creek, the decisions in the basin are dependent on a large number of factors. These factors include maintaining service to existing customers, adding capacity for future growth, and capacity issues in the MBC system. The costs below are based on the capitol improvements required and the cost of the City's ongoing I&I reduction program.

5.4.1 COSTS WITH PEAK FLOW

Table C.1 in Appendix C provides an opinion of probable costs for the proposed improvements. Provided within the table is a capitol improvement cost of approximately $7,040,000 that a future expansion would require. Also included within this estimate is the capital cost for an aggressive basin wide rehabilitation program. This estimate brings the total anticipated cost for this scenario to approximately $9,242,000.

5.4.2 COSTS WITH 30% I&I REDUCTION

Table C.2 in Appendix C provides an opinion of probable costs for the proposed improvements. Provided within the table is a capitol improvement cost of approximately $7,745,000 that a future expansion would require. Also included within this estimate is the capital cost for an aggressive basin wide rehabilitation program. This estimate brings the total anticipated cost for this scenario to approximately $7,979,000.

5.4.3 COSTS WITH 0% I&I REDUCTION

Table C.3 in Appendix C provides an opinion of probable costs for the proposed improvements. Provided within the table is a capitol improvement cost of approximately $7,918,000 that a future expansion would require. Also included within this estimate is the capital cost for an aggressive basin wide rehabilitation program. This estimate brings the total anticipated cost for this scenario to approximately $7,918,000.

5.4.4 COSTS OF 24-INCH INTERCEPTOR

Table C.4 in Appendix C provides an opinion of probable costs for the proposed improvements. Provided within the table is a capitol improvement cost of approximately $5,395,000 that a future expansion would require. Also included within this estimate is the capital cost for an aggressive basin wide rehabilitation program. This estimate brings the total anticipated cost for this scenario to approximately $5,629,000.

5.5 RECOMMENDATIONS

Improvements recommended in this basin in the 2004 Master Plan were limited to rehabilitation of the existing sewer system in order to reduce I&I. No additional recommendations where made in this service area.

Three possible scenarios were reviewed in this report: Peak Flow condition (100% excess I&I reduction), 30% I&I reduction and 0% I&I reduction. Based on these I&I reduction levels, future flow projections were generated and new interceptors were sized. Table 5.10 summarizes the capitol improvement costs.

Table 5.10 Summary of Alexander Creek Interceptor Costs

I&I	Cost
Peak Flow*	$7,039,778
30% Reduction	$7,745,355
0 % Reduction	$7,917,885

* 100% Excess I&I Reduction

However, it is inappropriate to compare these three scenarios based solely on capitol costs alone. The costs of the I&I reduction program must be considered with the capitol costs of the new sewer system. The total costs for the Alexander Creek Basin would include costs to build a larger interceptor and the costs of the I&I program as tabulated in Table 5.11.

Table 5.11 Summary of Alexander Creek Area Improvements

I&I	Cost
Peak Flow*	$9,241,778
30% Reduction	$7,979,355
0 % Reduction	$7,917,885

Based on Table 5.11, the least expensive option at this time is not to reduce I&I. However, this table assumes that the I&I problem does not grow worse over time and ignores choked flow conditions that would cause the sewers to back up. In addition, the capacity of the MBC interceptor is limited and there are no plans to expand it. Therefore, the recommended course of action is to continue with the current I&I reduction programs with the goal of 30% excess I&I reduction.

In light of the MBC sewer limitations, it is recommended that a 24-inch sewer be installed to support additional growth. Given the population projections for Alexander Creek, it will be 40 years before the 24-inch sewer will reach capacity. As that time approaches, the City will have more information about development density and sewer flows. It can be decided at that time whether an excess flow pump station or an enlarged sewer is the best option for future growth. Table 5.12 updates Table 5.11 to include this alternative.

Table 5.12 Revised Summary of Alexander Creek Area Improvements

I&I	Cost
Peak Flow*	$ 9,241,778
30% Reduction	$ 7,979,355
0 % Reduction	$ 7,917,885
Alternative	
30% Reduction and 24-inch	$ 5,629,140

Therefore, the most cost effective alternative for the City is to replace the existing 18-inch diameter interceptor with a 24-inch diameter interceptor. This will provide connections for 40 years worth of development growth. As the City approaches capacity, it can evaluate future service needs.

The City has indicated that the estimated cost for this 24-inch capital improvement as a single project is not available at this time but requested a review of this project as a multiphase project. If this project is broken down into approximately 1/3 size phases, each phase will be approximately 8,000 feet long. The first phase will be of sufficient length to take flows from the proposed school and the Hollyday Farms development without impacting capacity of the upper reaches of Alexander Creek. Assuming an I&I reduction rate of 15%, the capacity available in the 18-inch portion of the Alexander Creek Interceptor is 2,166 connections while approximately 7,948 connections are available in the 24-inch portion of the Alexander Creek Interceptor. In addition, if mild surcharging were acceptable, the capacity in the 18-inch portion of the interceptor would be 2,366 connections. These additional 200 connections would not be possible if the lower 8,000 feet of ACI were not enlarged to 24-inches.

6.0 WHITETAIL RUN POPULATION / FLOW PROJECTION

6.1 BACKGROUND

Whitetail Run drainage basin is located immediately east of US 71 and south of the watershed served by the Owen-Good Pump Station. The existing Whitetail Run interceptor extends from the development in the middle of the basin to a pump station near the western edge of the City of Raymore's current city limits which discharges to the Owen-Good Pump Station. The basin is shown in Figure 2.1.

6.2 POPULATION / FLOW PROJECTION

For this report, population figures for the Whitetail Run watershed were based upon information previously provided to the City. This ensures consistency with other, previously published documents and prevents duplication of effort. This area was referred to as Expansion Area A in the 2004 Master Plan.

6.2.1 ASSUMPTIONS

For this report, it is assumed that 90% of the land in the Whitetail Run basin will be developed. Undeveloped land is land unsuitable for construction such as flood plains or storm water detention areas.

Where population projections in the referenced studies did not have a sufficient time horizon, a 4% growth rate was assumed after existing projections ended and all flows were assumed to come from growth inside the Whitetail Run watershed.

In accordance with the 2004 Master Plan, this report makes several assumptions. Based on 2000 census data, an average of 2.76 people per home is projected. Each of these inhabitants will use an average of 100 gallons of water. This report also is based on an average density of two and one half homes per acre which is the approximate density of the Whitetail Run subdivision.

Contributions from commercial flows are assumed to be 15% of residential flows.

The following is a summary of assumptions made for Whitetail Run calculations:

- Only 90% of the land in the Whitetail Run is assumed to be developable.
- Population is defined as 2.76 people per home.
- Average density is 2.5 homes per acre, using the density of the new Whitetail Run subdivision as a basis.
- Commercial flow contributed is assumed to be 15% of residential flow.
- The growth rate in Whitetail Run is assumed to be 25 homes per year until 2018.
- The growth rate in Whitetail Run is assumed to increase 4% per year beyond 2009.
- Wastewater flow is 100 gallons per capita per day
- I&I is accounted for in the peaking factor due to the young age of the wastewater facilities in the basin.

6.2.2 CALCULATIONS

The two main considerations when designing sanitary sewer interceptors are alignment and capacity. WCI assumed an alignment parallel to the existing stream corridor for simplicity. The primary factors that influence capacity are pipe slope and pipe roughness. WCI has assumed the new line will have a 0.02% slope which is a conservative slope in contrast to existing average grade of 0.06% slope. The lesser slope was chosen to denote a minimum slope as the minimum slope controls the capacity of an interceptor, not the average slope. Actual design may change the pipe location from those shown. Pipe roughness from existing Raymore design standards was used and our analysis skewed toward more economical and corrosion resistant PVC in the small line sizes used in this basin.

Three calculations were developed for this basin. The first calculation reviews the current capacity of the existing Whitetail Run Interceptor using as-builts provided by the City. The second calculation determines the flow expected to be generated within the basin. Finally, the interceptor diameter required for ultimate build-out was determined.

Standard design criteria required by the City of Raymore and the Missouri Department of Natural Resources (MDNR) use a peak flow factor to determine appropriate pipe diameter to account for typical infiltration and peak houly flow. As the facilities in this basin are less than five years old, the peaking factor provided by Equation 4.1 was used for this calculation.

6.3 RESULTS

The first calculation developed for this area is the current capacity of the existing Whitetail Run interceptors. Using as-built drawings to find manhole inverts, the slope of each segment of pipe was calculated. From this information, the capacity of the existing line was determined. (See Table 6.1) The second calculation determines the flow expected to be generated within the basin based upon population projections. Last, the interceptor diameter required for ultimate build-out at an assumed slope of 0.2% was determined by employing Equation 4.2.

Next, WCI calculated the expected peak flow. WCI developed flows based on projected populations using the assumptions discussed in "6.2.1 Assumptions." As this line is less than five years old, all I&I was accounted for by the peaking factor. (See Table 6.2.)

Finally, calculations were developed to determine the required pipe diameters of the Whitetail Run Interceptor at ultimate development based on the tabulated flows. (See Table 6.3.)

The existing Whitetail Run interceptor pipe diameter is 21-inches at the pump station and 18-inches where it terminates near the Whitetail Run Subdivision.

Based on the minimum slope of 0.28%, a maximum capacity of 7.21 cubic feet per second (cfs) can be calculated for the 18-inch portion of the interceptor. Even with the possible discharges from the western sub-basin in Expansion Area B, it is anticipated that the existing interceptor in the Whitetail Run basin is sufficient size for ultimate build-out of the basin.

The calculations presented are based upon the design assumptions listed above. Growth conditions can change extending or decreasing the times frames discussed above. Table 6.4 lists the population projections through 2040 as well as the projected ultimate build-out.

Table 6.4 Population Projection – Whitetail Run

Year	Whitetail Run
2015	1,780
2020	3,188
2025	4,899
2030	6,983
2035	9,525
2040	12,619
Ultimate	14,349

6.4 COSTS

The existing infrastructure is sufficient for ultimate build-out. Therefore, no cost decision is associated with this analysis.

6.5 RECOMMENDATIONS

Assuming the western sub-basin of Expansion Area B begins to develop, flows should be conveyed to the Whitetail Run Interceptor for treatment and discharge.

7.0 EXPANSION AREAS B & C

7.1 BACKGROUND

Expansion Area B is located between US 71 and Highway 291, sandwiched between Whitetail Run and Expansion Area C. As such, it does not have easy access to either highway. In addition, growth tends to begin at major highway intersections and grow away from them. Therefore, it is believed that Area B shall begin to develop after Whitetail Run and Expansion Area C.

Expansion Area C is located along Highway 291, south of the Alexander Creek drainage basin. This basin drains into Middle Big Creek. Due to its proximity to the highway and the proposed rerouting of Highway 58, it is believed that Area C will begin growing from Alexander Creek to the south. However, development in this area will lag slightly growth in Whitetail Run.

7.2 POPULATION / FLOW PROJECTION

For this report, population figures for the Expansion Area B & C watersheds were based upon information previously provided to the City in the 2004 Wastewater Master Plan. This ensures consistency with other, previously published documents and prevents duplication of effort.

Using population density acquired from the previous studies and City of Raymore design standards, flows in the expansion areas were analyzed for future capitol improvement requirements.

7.2.1 ASSUMPTIONS

For this report, it is assumed 90% of the land in Expansion Areas B & C will be developed. Undeveloped land is land unsuitable for construction such as flood plains or storm water detention areas.

In accordance with the 2004 Master Plan, this report makes several assumptions. Based on 2000 census data, an average of 2.76 people per home is projected. This report also is based on an average density of two and one half homes per acre which is the approximate density of the Whitetail Run subdivision. This lower density reflects the current thinking in housing construction.

Each of these inhabitants will use an average of 100 gallons of water. Contributions from commercial flows are assumed to be 15% of residential flows.

The following assumptions were made for Expansion Areas B & C calculations:

- Only 90% of the land in the Expansion Area B & C is assumed to be developable.
- Population is defined as 2.76 people per home.
- Average density is 2.5 homes per acre, using the density of the new Whitetail Run subdivision as a basis.
- Commercial flow contributed is assumed to be 15% of residential flow.
- Wastewater flow is 100 gallons per capita per day
- I&I is accounted for in the peaking factor as there is no existing infrastructure and it is assumed new construction standards and techniques will be applied to prevent I&I.

7.2.2 CALCULATIONS

The two main considerations when designing sanitary sewer interceptors are alignment and capacity. WCI assumed an alignment parallel to the existing stream corridor for simplicity. The primary factors that influence capacity are pipe slope and pipe roughness. WCI has assumed the new line will have a 0.02% slope which is a conservative slope in contrast to existing average grade of 0.06% slope. The lesser slope was chosen to denote a minimum slope as the minimum slope controls the capacity of an interceptor, not the average slope. Actual design may change the pipe location from those shown. Pipe roughness from existing Raymore design standards was used in the Manning's formula to determine capacity and our analysis skewed toward more economical and corrosion resistant PVC in the small line sizes used in this basin.

The interceptor diameter required to serve Expansion Areas B & C were determined. As tabulated previously in the 2004 Raymore Wastewater Master Plan, the interceptor diameters were sized based on ultimate build-out.

Standard design criteria required by the City of Raymore and the Missouri Department of Natural Resources (MDNR) use a peak flow factor to determine appropriate pipe diameter to account for typical infiltration and peak hour flow. As there are not any facilities serving this basin currently, the peaking factor provided by Equation 4.1 was used for this calculation.

7.3 RESULTS

Calculations were developed to determine the required pipe diameters of the Expansion Area B & C Interceptors at ultimate development based on tabulated flows and slope by using Equation 4.2. The flows and peaking factor are based on the area served and the assumed basin population. (See Table 7.1 and Table 7.2.)

These calculations concur with previous interceptor sizing from the 2004 Wastewater Master Plan. The two expansion areas where analyzed separately for required interceptor capacity above.

The calculations presented are based upon the design assumptions listed above. Growth conditions can change extending or decreasing the times frames discussed above. Table 7.3 lists the population projections through 2040 as well as the projected ultimate build-out.

Table 7.3 Population Projection – Expansion Areas

Year	Expansion Area B	Expansion Area C
2,015	-	3,324
2,020	-	6,350
2,025	-	12,216
2,030	-	19,883
2,035	5,001	24,884
2,040	6,521	36,405
Ultimate	*28,476	42,855

7.3.1 EXPANSION AREA B

Area B naturally drains to the south, into basins currently served by the City of Peculiar's Wastewater Treatment Facility. While building a pump station would be an acceptable temporary solution until gravity sewers can be constructed for the western sub-basin of Area B, there would be substantial capitol costs to install the required pump station and force main for the central and eastern sub-basins in Area B. Another possibility is to pay the City of Peculiar to convey, treat, and discharge as an alternative.

However, the current City of Peculiar wastewater system services only as far north as 211^{th} Street with and 8-inch diameter line. Based on the size of Area B, this line size is not sufficient to serve Area B or the drainage basin in the City of Peculiar. To serve the areas shown as contributing to proposed pump station B-2, located as shown in Figure 7.1 - Figure 7.3, a 24-inch diameter interceptor would be needed. When the City does begin to receive pressure to allow Area B to develop, the City of Peculiar may be in a position to provide conveyance and treatment for the flows collected the proposed interceptors in Area B.

7.3.2 EXPANSION AREA C

A key difference in the growth in this area as indicated by this report as opposed to the 2004 Master Plan is the ability to sewer the area with flows conveyed to MBC. This difference is a result of Middle Big Creek's (MBC's) proposed interceptor that will take flows currently collected by the Winnebago Pump Station and transmit them to the proposed MBC treatment facility near the City of Pleasant Hill. When this interceptor is completed and a new trunk line installed by the City, the need for one of the proposed pump stations from the 2004 Master Plan will be eliminated. In addition, serving the remaining basins in Area C will require fewer feet of force main, significantly reducing costs for the City.

7.3.3 PUMP STATION FLOWS

Pump stations are to be size sufficiently when designed as to handle the expected flows of the basin they serve for the next thirty years as required in the scope. Pump stations will need to be installed at the same time as the interceptor discharging into them.

In order to maintain a scouring velocity of two feet per second, as required by MDNR, it may be necessary to install a smaller force main than needed for full basin build-out. When scouring velocities can not be achieved, solids deposit in low spots of the pipe and block or reduce pipe flow capacity. Since full basin build-out is generally a slow process, pump stations and force-mains need to be built with room for future expansion.

This report reviews three different options for flow conveyance. Option 1 conveys all the flows from Area C as well as central and eastern Area B and discharges to the proposed Middle Big Creek Interceptor. Option 2 discharges all of Area C to the proposed Middle Big Creek Interceptor while transferring flow from Area B to the Owen-Good Pump Station. Option 3 discharges all flows from Area B & C to the Owen-Good Pump Station, the course of action recommended by the 2004 Master Plan.

Population growth for Whitetail Run has been as indicated in “7.2.1 Assumptions.” In addition, the Creekmore Subdivision is assumed to add approximately 150 homes a year over ten years to the existing service areas north of Highway 58. Additional population growth beyond the amounts indicated above will likely apply pressure for new development in the

Expansion Areas B & C. Table 7.4 indicates anticipated growth of the Whitetail Run and the Expansion Areas.

Table 7.4 Population Projection – Growth Areas

Year	Whitetail Run	Expansion Area B	Expansion Area C	Yearly Total
2,015	1,780	-	3,324	5,104
2,020	3,188	-	6,350	9,538
2,025	4,899	-	12,216	17,115
2,030	6,983	-	19,883	26,866
2,035	9,525	5,001	24,884	39,410
2,040	12,619	6,521	36,405	55,545
Ultimate	14,349	*28,476	42,855	*85,710

* Includes approximately 3,200 persons outside of Expansion Area B, but within watershed.

The populations indicated above were tabulated to calculate the required pipe and pump station sizes to serve the expansion areas. Calculations follow the assumption employed throughout the report of 100 gallons per capita day and are summarized in Table 7.5.

Table 7.5 Resultant Flows – Expansion Areas

Pump Station	Average Flow (mgd)	Peak Flow (mgd)
B1	0.10	0.30
B2	0.55	1.66
C1	1.65	4.95
C2	0.94	2.82
C1-A	1.05	3.15

The calculations presented are based upon the design assumptions listed above. Growth conditions can change extending or decreasing the times frames discussed above.

7.3.3.1 OPTION 1

This option results in a majority of future flows from Expansion Areas B & C being conveyed by the proposed MBC interceptor to the proposed treatment facility in Pleasant Hill. Based on these flow patterns, the Table 7.6 was developed to illustrate force main sizes.

Table 7.6 Option 1 Force Main Sizing

Force Main	Peak Flow (mgd)	Diameter (in)
B1	0.30	6
B2	1.66	12
C1	4.95	20
C2	2.82	16
C2 & B2	4.48	20
C1, C2 & B2	9.43	30

All proposed improvements for Option 1 are represented graphically in Figure 7.1. This option provides for the conveyance for all future flows from Areas B & C to the proposed MBC Wastewater Treatment Facility in Pleasant Hill. One key advantage of this option over Option 3 is the elimination of a pump station as well as the associated operations and maintenance. An additional benefit of this option is the ability to route additional development flows to the proposed facility immediately. Finally, this option avoids the problems associated with over sizing force mains that can lead to settling and clogging issues.

7.3.3.2 OPTION 2

This option results in future flows from Expansion Area C being conveyed by the proposed MBC interceptor to the proposed treatment facility in Pleasant Hill. All other flows are conveyed directly or indirectly to the Owen-Good Pump Station. Based on these flow patterns, the Table 7.7 was developed to illustrate force main sizes.

Table 7.7 Option 2 Force Main Sizing

Force Main	Peak Flow (mgd)	Diameter (in)
B1	0.30	6
B2	1.66	12
C1	4.95	20
C2	2.82	16
C1 & C2	7.77	24

All proposed improvements for Option 2 are represented graphically in Figure 7.2. This option provides for the conveyance for all future flows from Areas B & C to the proposed MBC Wastewater Treatment Facility in Pleasant Hill. One key advantage of this option over Option 3 is the elimination a pump station as well as the associated operations and maintenance costs associated with a pump station. An additional benefit of this option is the ability to route additional development flows to the proposed facility immediately. Finally, this option avoids the problems associated with over sizing force mains that can lead to settling and clogging issues.

7.3.3.3 OPTION 3

This option results in future flows from Areas B & being conveyed to the Owen-Good Pump Station. Flow from Whitetail Run also continues to flow to the Owen-Good Pump Station. Based on these flow patterns, the Table 7.8 was developed to illustrate force main sizes.

Table 7.8 Option 3 Force Main Sizing

Force Main	Peak Flow (mgd)	Diameter (in)
B1	0.30	6
B2	1.66	12
C1	4.95	20
C2	2.82	16
C1-A	3.15	16
C1 & C1-A	8.10	30
Area C	10.92	30
Area C & B2	12.58	36

All proposed improvements for Option 3 are represented graphically in Figure 7.3. This option provides for the conveyance for all future flows from Areas B & C to the proposed Owen-Good Pump Station. This option is very similar to what was recommended in the 2004 Master Plan prior to the MBC expansion being proposed. This option requires a pump station not required by Options 1 & 2 but eliminates the need for the MBC Trunk Sewer 1B as detailed in the Archer February 25, 2008 memo. See Figure 7.3.

7.4 COSTS

Due to the lack of service in Expansion Areas B & C, the decisions in the Expansion Areas are much simpler. Choices made for serving these areas can be restricted to cost and development pressure as there are no existing facilities to incorporate. This report details our opinion of development pressure in "4.0 Population Projections."

7.4.1 OPTION 1

Overall costs are tabulated in Table C.5 included in Appendix C for the improvements shown in Figure 7.1. Table 7.9 provides a proposed capitol improvement schedule and probable cost for Option 1. Total cost for these improvements is estimated to be approximately $27,145,000. Additional costs of $4,616,000 would be incurred to finance the construction of the MBC interceptor. This value is based upon MBC estimates of Raymore portion of the cost to install the proposed MBC interceptor to Pleasant Hill as well as wastewater treatment facility expansions. The cost for the MBC interceptor was estimated from the Table 3a from the Archer Memorandum dated February 25, 2008.

7.4.2 OPTION 2

Overall costs are tabulated in Table C.6 included in Appendix C for the improvements shown in Figure 7.2. Table 7.10 provides a proposed capitol improvement schedule and probable cost for Option 2. Total cost for these improvements is estimated to be approximately $27,681,000. Additional costs of $4,616,000 would be incurred to finance the construction of the MBC interceptor. This value is based upon MBC estimates of Raymore portion of the cost to install the proposed MBC interceptor to Pleasant Hill as well as wastewater treatment facility expansions. The cost for the MBC interceptor was estimated from the Table 3a from the Archer Memorandum dated February 25, 2008.

7.4.3 OPTION 3

Overall costs are tabulated in Table C.7 included in Appendix C for the improvements shown in Figure 7.3. Table 7.11 provides a proposed capitol improvement schedule and probable cost for Option 3. Total cost for these improvements is estimated to be approximately $29,790,000. Under this scenario, flows will need to be treated by a new wastewater treatment facility as discussed below in "8.0 Treatment Alternatives" or require expansion of LBVSD's facilities. The costs for LBVSD were not estimated as the required data is not available. It is expected that LBVSD will not improve their facilities.

7.5 RECOMMENDATIONS

Three options were proposed for directing flows from the Expansion Areas to be treated. The first option involved conveying flows from Areas B & C to the proposed Middle Big Creek (MBC) facility. The second option shows that Area C continues to transfer flow to the proposed MBC facility while Area B is serviced entirely by pumping to the east. The third option reflects the previous flow transfer option recommended to the City prior to the proposal of the MBC facility.

An Opinion of Probable Cost was developed for the total infrastructure needs of each alternative. Opinions of Probable Cost are based on the following:

1. Interceptors are to be buried at an average of fifteen feet with the lowest five feet in rock. Blasting of rock is acceptable and debris disposal is five miles or less from the project site.
2. Three phase power is available at sites near existing Highway 291 as well as near the proposed Highway 58.
3. Three phase power will be routed to Pump Station B-2 from along the proposed Highway 58.
4. Pump Station B-1 will be provided three phase power via a feed from the site of Pump Station B-2
5. All pump stations will be equipped with emergency diesel generators.

Table 7.12 summarizes the costs associated with the three improvement options. The cost per connection is based upon 20,125 connections or a population of 55,545 in the year 2040.

Table 7.12 Summary of Expansion Area Costs

Option	Cost	Cost per Connection
1	$27,144,501	$1,349
2	$27,681,261	$1,375
3	$29,789,691	$1,480

As can be seen from the table above, the cost associated with option 3 is substantially higher than the other options even though all options include the same interceptor costs. A substantial cause of this difference is the requirement of an additional pump station in Option 3.

Based on the lower cost, it is recommended that the City of Raymore proceed with planning to construct Option 1. This option requires the least capitol investment and does not require the additional pump station in Expansion Area C.

8.0 TREATMENT ALTERNATIVES

8.1 BACKGROUND

Treatment of wastewater flows represent a challenge to the City of Raymore due to its geography and legal considerations. The City and proposed annexation areas straddle several major ridgelines making it difficult to serve the City without a significant investment in pump stations. In addition, areas generally north of US 58 lie within the Little Blue Valley Sewer District (LBVSD) or the Middle Big Creek Sub District (MBCSD), complicating service issues. Areas within the LBVSD service area must, by agreement, be served by the LBVSD. Areas within the MBCSD service area may be served by MBC facilities or the flows may be conveyed to another facility for treatment.

8.2 POPULATION / FLOW PROJECTION

For the purpose of conducting an evaluation of alternatives, the costs will assume all flows from the expansion areas are conveyed, along with the flows from the Owen-Good Pump Station, to a single point for treatment.

8.2.1 ASSUMPTIONS

The flow of 4.5 MGD from the Owen-Good Pump Station was extracted from the 2004 Wastewater Master Plan. This ensures consistency with other, previously published documents and provides a point of reference between this report and the 2004 Master Plan. Flow from Whitetail Run and Expansion Areas B & C were the future flows indicated previously in the report.

8.2.2 CALCULATIONS

Operations and Maintenance costs were converted into a present worth assuming an inflation rate of 6% and the costs split into two phases, with each phase lasting 15 years. This 30 year total represents the time horizon of this report.

8.3 RESULTS

In order to analyze the costs associated with wastewater treatment, this report will review four different alternatives. The first alternative will review the efforts and costs associated with development of a city owned wastewater treatment facility. The second alternative will review conveying the wastewater flow to the City of Belton's treatment plant via force main to continue utilizing existing pump stations in the Whitetail Run and Owen-Good basins. The third alternative reviewed also conveys the wastewater flow to the City of Belton's treatment plant but uses a gravity main instead of a force main. The final alternative reviewed continues the City's current practice of discharging to LBVSD.

8.3.1 RAYMORE WASTEWATER TREATMENT FACILITY

The 2004 Master Plan Report was evaluated assuming the new treatment facility would be built at the existing Owen-Good Pump Station site. After completing an upgrade to the pump station, the City does not own enough room at the site to support the footprint of a new treatment facility. Therefore, this report will evaluate a treatment facility located at the Whitetail Run Pump Station Site. It is anticipated that both the Whitetail Run and Owen-Good Pump Stations will pump directly to the headworks of the proposed treatment facility, saving the City the cost of a new lift station for the proposed facility and allowing the City to continue using the new and recently upgraded pump stations indicated above. The facility would consist of the following processes:

- Equalization Basin
- Screening with Grit and Scum Removal
- Influent Sampling and Flow Measurement
- Activated Sludge Facilities
- Nutrient Removal
- Scum and Sludge Removal
- Sludge Thickening, Digestion, Dewatering, Storage, and Disposal

- Effluent Disinfection
- Effluent Sampling and Flow Measurement

The treated and disinfected wastewater effluent would then be discharged to East Creek.

Prior to obtaining the required NPDES permit for a treatment facility from the Missouri Department of Natural Resources (MDNR), the City would be required to perform an antidegradation study on the receiving water body. Included within this study is approximately a year of water quality monitoring at locations approximately one half mile upstream and downstream of the proposed treatment facility outfall structure. This antidegradation study would be used to set discharge limits of pollutants such as BOD, TSS, ammonia, E. Coli, dissolved oxygen, and various metals for the receiving stream. Treatment facility design would be based on the required removal of these pollutants and is tough to guess. Since the City of Belton currently discharges to the same stream, their current limits may serve as an example. The NPDES Permit discharge limits currently applied to the City of Belton, listed in Table 8.1, or more stringent limits, are likely to be applied to any new treatment facility built by the City of Raymore.

Table 8.1 City of Belton NPDES Permit Discharge Limits

Parameter	Daily Maximum	Monthly Average
BOD, mg/L	20	20
TSS, mg/L	45	30
Ammonia-Nitrogen, mg/L	3.7	1.5
Oil & Grease, mg/L	15	10
pH	6 - 9	
Fecal Coliform, # / 100 mL	100*	100*

* Less stringent limits apply outside of recreational season (October – April).

The treatment facility would be a mechanical activated sludge treatment facility with ultraviolet (UV) radiation. UV treatment eliminates the need to store disinfection chemicals on site, eliminates concerns about disinfection byproducts, eliminates the need to dechlorinate, and does not pose the kind of safety hazard to City Personnel that a chemical spill would represent. The activated sludge design would include both aerobic and anoxic zones to provide for nutrient removal such as nitrogen and phosphorus. While phosphorus is not listed in Table 8.1, the EPA has recently begun tightening water quality standards and it is believed that this nutrient would be included in a NPDES permit for a city run treatment facility.

8.3.2 EXISTING BELTON WASTEWATER TREATMENT FACILITY – FORCE MAIN

Another choice for the City is to convey the flow from the Whitetail Run and Owen-Good Pump Station to the City of Belton's wastewater treatment facility with a force main. Flow rates and service projections are assumed the same as "8.3.1 Raymore Wastewater Treatment Facility" and all flows are assumed to be consolidated at the Owen-Good Pump Station. This alternative would require a new force main as well as improvement to some existing City of Belton facilities but would allow for continuing service by the new Whitetail Run Pump Station and recently upgraded Owen-Good Pump Station. Basic capitol costs include:

- A force main measuring 36 inches in diameter and approximately 20,500 feet in length.
- Upgrades to increase the Belton pump station's pumping capacity.
- Expansion of the Belton WWTF's capacity by 6.1 mgd.

In addition to the capitol costs above, the City of Raymore will be required to contribute to the operation and maintenance of the wastewater treatment facility.

8.3.3 EXISTING BELTON WASTEWATER TREATMENT FACILITY – INTERCEPTOR

A third choice for the City is to convey the flow from the Whitetail Run and Owen-Good Pump Station to the City of Belton's wastewater treatment facility with interceptors. Flow rates and service projections are assumed the same as "8.3.1 Raymore Wastewater Treatment Facility" and all flows are assumed to be consolidated at a manhole downstream from the Whitetail Run and Owen-Good Pump Stations. This alternative would require a new force main as well as improvement to some existing City of Belton facilities. Basic capitol costs include:

- An interceptor measuring 48 inches in diameter and approximately 17,500 feet in length.
- A force main measuring 36 inches in diameter and approximately 3,000 feet in length from the receiving pump station to the Belton WWTF.
- Upgrades to increase the Belton pump station's pumping capacity.
- Expansion of the Belton WWTF's capacity by 6.1 mgd.

In addition to the capitol costs above, the City of Raymore will be required to contribute to the operation and maintenance of the wastewater treatment facility.

8.3.4 LBVSD WASTEWATER TREATMENT FACILITY

The final option is to continue existing service by the LBVSD. Recently completed upgrades as recommended by the 2004 Master Plan to the Owen-Good Pump Station (a capacity increase and the construction of an additional excess flow holding basin) can be utilized to support this option. The two costs associated with this option, based on current capitol assets, are the construction costs for expanding the pump station's force main as needed and the costs paid to LBVSD for the operations and maintenance of the existing wastewater facilities.

8.4 COSTS

For the purposes of a cost comparison, it is assumed Option 3 is selected. This is to ensure that sufficient flows exist to support the costs of a full size wastewater treatment facility.

8.4.1 RAYMORE WASTEWATER TREATMENT FACILITY

A preliminary opinion of probable costs is included in Table C.8 in Appendix C. The costs for this option will range between $6 and $9 per gallon treated, depending upon treatment requirements. A Phase I wastewater treatment facility of 3.05 Million Gallons per Day (MGD) is expected to cost in the range of $24,705,000 to $37,057,500. A Phase II wastewater treatment facility expansion of an additional 3.05 MGD is expected to cost in the range of $16,470,000 - $20,587,500. The City will need to perform a preliminary engineering study and review with MDNR and then proceed with an antidegradation study. It is estimated the costs of this option's present worth cost would range from $56,435,000 to $74,079,000.

8.4.2 EXISTING BELTON WASTEWATER TREATMENT FACILITY – FORCE MAIN

A preliminary opinion of probable costs provided in Table C.9 in Appendix C. The costs for this option assume a cost of $4 per gallon treated. It is estimated this option's present worth cost is $55,389,000.

8.4.3 EXISTING BELTON WASTEWATER TREATMENT FACILITY – INTERCEPTOR

A preliminary opinion of probable costs is tabulated in Table C.10 in Appendix C. The costs for this option assume a cost of $4 per gallon treated and creek crossings would be minimal. It is estimated this option's present worth cost $61,480,000.

8.4.4 LBVSD WASTEWATER TREATMENT FACILITY

A preliminary opinion of probable costs is tabulated in Table C.11 in Appendix C. The costs for this option include the payments to LBVSD, which are detailed further in Table C.12. It is estimated the present worth of this option is $44,890,882.

8.5 RECOMMENDATIONS

Several alternatives for treatment of wastewater flows generated within the City were evaluated including:

- Building a treatment facility to service the City of Raymore
- Conveying wastewater flows to the City of Belton's WWTF with a force main, keeping Whitetail Run and Owen-Good Pump Stations in operation
- Conveying wastewater flows to the City of Belton's WWTF with an interceptor, decommissioning Whitetail Run and Owen-Good Pump Stations.
- Continuing the current practice of pumping wastewater flows to the LBVSD's facilities for treatment.

In addition to the summary of costs presented in Table 8.2, the following item should be kept in mind. Working with Belton is similar to the current situation with LBVSD in that the City of Raymore would simply be paying another party to treat their wastewater with the difference merely being cost. The ultimate affect is that the Belton alternatives should be reevaluated when ever significant capitol improvements are required and when the Whitetail Run and Owen-Good Pump Stations approach the end of their design lives.

Table 8.2 Summary of Treatment Alternative Costs

Alternative	Cost
Raymore WWTF	$56,435,000 - $74,079,000
Belton WWTF - Force Main	$55,389,000
Belton WWTF - Interceptor	$61,480,000
LBVSD WWTF	$44,890,882

Based on the present worth comparison provided in Table 8.2, the preferred conveyance and treatment alternative is to continue pumping to the LBVSD collection system. Currently, there is insufficient data completely analysis the treatment and conveyance options. This report will be finalized when that information is made available.

It is recommended that no decision be made on the conveyance of flows to the proposed Raymore WWTF or to the City of Belton's WWTF until completion of an antidegradation study. This study will be needed to provide a more accurate analysis of the costs.

9.0 SUMMARY OF RECOMMENDATIONS

9.1 GENERAL

Based on the analysis above, this section of the report provides recommendations regarding improvements, costs of alternative flow conveyance and future treatment options.

9.2 ALEXANDER CREEK

It is recommended that the City continue pursuing an I&I reduction program. This program will free up capacity delaying the time when capacity is exceeded. This is particularly important as the capacity is needed to allow for continued growth, particularly the new school and the Hollyday Farms development. A secondary advantage to the I&I program is the reduced potential for overflows and backups.

It is also recommended that capacity expansion in the Alexander Creek basin be a 24-inch diameter interceptor. This size sewer will provide 40 years of capacity based on the projected population growth while avoiding the problems associated with conveying flow from a trunk line to a smaller interceptor. The costs for this project could be more easily managed with the three phase approach discussed in “5.5 Recommendations.”

9.3 EXPANSION AREAS

Due to the young age and resulting negligible I&I in Whitetail Run and the lack of service in Expansion Areas B & C, the decisions in the Expansion Areas are rather simple. Choices made for serving these areas can be restricted to cost and development pressure. This report details our opinion of development pressure in “4.0 Population Projections.”

9.3.1 RAYMORE TO SERVE TO AREA B

Based on the costs indicated in this report, Option 1 is recommended. This option allows for significantly lower capitol costs than Option 3 due to the elimination of a pump station. This reduces the operations and maintenance costs for the City. Option 1 also requires 6,450 fewer feet of force main than was required for Option 2. Therefore, the lower cost Option 1 is recommended.

9.3.2 PECULIAR TO SERVE TO AREA B

Option 1 was recommended above due to the potential cost savings. The cost savings of Option 1 could be further enhanced with the elimination of either or both pump stations B-1 and B-2. These two pump stations and their associated force mains would not be required if capital improvements were completed to the City of Peculiar's wastewater system, resulting in a savings of $6,378,815. The total cost for Option 1 without pump stations B-1 and B-2 is $20,765,687.

The City of Peculiar has indicated a desire to work with the City of Raymore to service Area B. This report recommends the City of Raymore continue discussions with the City of Peculiar to provide for sewer service to Area B without the expense of constructing, maintaining, and operating these pump stations. While the City of Raymore may be asked to assist with the improvements required to the City of Peculiar's wastewater system, it is believed that the City of Raymore will realize substantial long-term savings.

9.4 TREATMENT ALTERNATIVES

Finally, a review of conveyance and treatment alternatives was conducted. Ultimately, there is a price premium for the City to build a treatment facility to service only its citizens. Significant capitol improvement costs would also be incurred if the City were to send wastewater flows to the Belton WWTF. However, some capitol improvements will be required by the City of ever increasing flows are to be conveyed to LBVSD's facilities for treatment.

This report recommends that the City continue pumping flows to the LBVSD collection system.

9.5 SUMMARY

Based on the recommendation above, a schedule of recommended improvements has been developed. The recommended improvements are provided in graphic form in Figure 9.1 and in tabular form in Table 9.1. The capitol improvements recommended provide the City with estimated budget numbers for the next thirty years but should be revisited if there are major changes to the assumptions used to prepare this report.

APPENDICES

APPENDIX A

MIDDLE BIG CREEK SUB DISTRICT:
POPULATION/CONNECTION PROJECTIONS

APPENDIX B

MDNR - NEWS RELEASE 221

APPENDIX C

OPINION OF PROBABLE COSTS