CITY COMMISSION AGENDA MEMO
May 6, 2008

FROM: **Jerry McIntyre, Deputy Director of Public Works**

MEETING: **May 13, 2008**

SUBJECT: **Wastewater Treatment Plant Upgrade and Expansion Project (SP0705)**

PRESENTERS: **Jerry McIntyre, Deputy Director of Public Works**
Patrick McCole, Carollo Engineers
Garrett Sheehan, Carollo Engineers

BACKGROUND

The City's wastewater treatment system consists of the Sanitary Sewer Collection System including several pump stations, a Wastewater Treatment Plant, and the City's Biosolids Farm.

The City's Wastewater Treatment Plant (WWTP) was originally constructed in 1974, and a major expansion was completed in 1998. The 1998 expansion increased the capacity of the WWTP from 6.2 MGD to 8.7 MGD on a peak month flow basis.

The WWTP provides influent screening, influent pumping, grit removal, conventional activated sludge treatment, and ultraviolet disinfection. Solids processes at the WWTP consist of aerobic digestion before sludge is pumped to the City's Biosolids Farm for land application.

The City's WWTP currently operates under a National Pollutant Discharge Elimination System (NPDES) permit. Permits normally last for five years. The current permit became effective on April 1, 2005, and will expire on March 31, 2010. The new permit requirements especially for nutrient removal will be more stringent than current requirements. Treatment improvements will be needed to meet those requirements.

The *Water and Wastewater Facilities Plans and Cost of Services Study*, completed in 2001, recommended that the City perform a WWTP upgrade and expansion of the plant to meet more stringent regulatory requirements, and to meet flows associated with projected population growth. The engineering for the WWTP upgrade and expansion is the project that is underway now.

In general, the project will address the WWTP hydraulic, organic, and nutrient loadings in order to meet present and future treatment demands, and ensure full compliance with current and anticipated discharge limits for the Wastewater Treatment Plant effluent.

The successful completion of this project should position the City's WWTP to accommodate anticipated future regulations, population growth within the City and adjacent areas, maintain reliable and effective treatment, and optimize operations in an efficient and cost effective manner.

On November 20, 2007, the City Commission authorized an agreement with Carollo Engineers for engineering services for the Wastewater Treatment Plant Upgrade and Expansion Project.

DISCUSSION

As an initial step in the project, Carollo Engineers has compiled a draft Preliminary Design Report (Report). Their work included a detailed evaluation of current and anticipated future hydraulic, organic, and nutrient loadings to the WWTP. Based on their evaluation, the report recommends improvements to meet present and potential future flow, as well as achieving full compliance with current and anticipated discharge limits for the WWTP effluent. The report will be used as the basis for the preparation of final construction drawings and specifications.

At the City Commission Work Session, Carollo Engineers will provide an update on the project, an overview of the Preliminary Design Report, and discuss the proposed next steps for the project.

ALTERNATIVE

It appears the Commission has the following alternative concerning the issue at hand. The Commission may:

1. Provide any direction deemed appropriate as the consultant proceeds to actual design.

RECOMMENDATION

City Administration recommends the City Commission provide feedback and direction based on the Preliminary Design Report.

POSSIBLE MOTION

No motion necessary since this is a work session.

Enclosure:

1. Draft Preliminary Design Report Executive Summary

JM/ie/08066

Chapter 1

EXECUTIVE SUMMARY

1.1 INTRODUCTION

The purpose of this project is to evaluate the hydraulic, organic, and nutrient loadings to the City's Wastewater Treatment Plant (WWTP) and develop recommendations for improvements required to meet present and potential future treatment flows as well as achieve compliance with current and anticipated discharge limits for the WWTP effluent and other environmental regulations. A summary of the findings, conclusions, and recommendations for the *Wastewater Treatment Plant Upgrade and Expansion Project* are presented in this Preliminary Design Report (PDR).

1.2 BACKGROUND

The City's wastewater treatment system consists of a sanitary sewer collection system including several pump stations, a wastewater treatment plant, and the City's Biosolids Farm. This PDR provides an evaluation of the wastewater treatment plant.

The City's WWTP has a rated capacity of 8.7 million gallons per day (MGD) and serves population within the present City limits of Manhattan and the immediate adjacent rural areas of Riley County and a small portion of Pottawatomie County. The existing facility shown in Figure 1 includes influent screening, pumping, grit removal, conventional activated sludge treatment (six aeration basins and three secondary clarifiers), solids handling (three aerobic digesters), and a UV disinfection system. A stormwater holding basin is also available for short-term storage during peak flow events. Originally constructed in 1974 with a capacity of 6.2 MGD, the plant was upgraded in 1998 to increase capacity to current levels. In 2004, upgrades to the solids handling facilities at the WWTP and Biosolids Farm were performed.

1.3 DESIGN CRITERIA DEVELOPMENT

Numerous planning studies have been prepared for the City in which the wastewater service area population has been projected. As late as the year 2000, the City commissioned a study by another consulting firm to project wastewater service area population. In 2006, the City retained Carollo to develop updated population projections for use in determining water system demand. This same population projection methodology developed by our team for the water system demand projections was used to develop wastewater service area population projections. A plot of the population projections developed by the Carollo team, as well as that presented in a previous study, is shown in Figure 2**.**

To determine future influent flows, historical per capita wastewater flow rates were applied to these population projections. Figure 3 shows estimated plant flow rates for both annual average day (AAD) and maximum month average day (MMAD) conditions. When comparing wastewater characteristics over multiple year periods, using an annual average for a calendar year is a very convenient and logical way to divide the data, and is accepted as a standard practice. However, by selecting the "maximum month" from a calendar year, a basis of design can be provided that allows effluent limits to be reliably achieved during every month of the year and is consistent with effluent limits that are typically based on monthly average values.

With the estimated flow projections complete, estimates of future organic and nutrient treatment plant loadings were developed. Figures 4 and 5 summarize design loadings and include wastewater loading contributions from non-residential users within the service area. These values will be used as the basis of design for the biological treatment process.

As shown in Figures 4 and 5, two non-residential users located at Kansas State University (KSU) have discharges with high organic and nutrient content that could potentially impact plant design. Discharges include effluent from an alkaline tissue digester operated by the College of Veterinary Medicine (Vet Med) as well as an alkaline tissue digester and effluent decontamination system (EDS) at the Biosecurity Research Institute (BRI). The waste from these processes is discharged into the City's sanitary sewer system per the terms of Memoranda of Understanding between the KSU and the City.

1.4 REGULATORY ANALYSIS

The WWTP currently operates under an NPDES permit (Kansas Permit No. M-KS38-0001, Federal Permit No. KS0036714) issued by the Kansas Department of Health and Environment (KDHE). A summary of the discharge requirements is presented in Table 1. This permit began effective on April 1, 2005, and will expire on March 31, 2010.

In December 2004, the Kansas Department of Health and Environment (KDHE) Bureau of Water prepared the Surface Water Nutrient Reduction Plan. The plan identified steps that must be taken to implement nutrient reduction in Kansas and protect the ecosystems in the Kansas River watershed and downstream water bodies. The plan indicated that nutrient reduction at wastewater treatment plants with flow in excess of 1 MGD would be required to achieve, at a minimum, total nitrogen (TN) limits of 8 mg/L and total phosphorus (TP) limits of 1.5 mg/L on an annual average basis with biological nutrient removal (BNR) technology.

As part of the plan implementation, KDHE requested that an analysis be performed on all new and expanded wastewater treatment plants to evaluate the impact of the new or expanded discharge on existing water quality and whether or not the impact to the community would be substantial and widespread. The analysis is also required to include various nutrient reduction levels based on five scenarios defined by KDHE as summarized in Table 2.

Table 1 Plant Effluent Discharge Limits
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

Effluent Parameter	Units	Effluent Limitations(2) Daily Maximum	Weekly Average	Monthly Average
BOD_5 (1)	mg/L	--	45	30
TSS (1)	mg/L	--	45	30
pH	Standard Units	6.0 - 9.0	--	--
Ammonia as N	mg/L			
(October - April)		12.4	--	12.4
(May)		12.4	--	10.3
(June)		12.4	--	8.0
(July)		12.4	--	6.3
(August)		12.4	--	6.8
(September)		12.4	--	9.3
Fecal Coliform (3)	Colonies/100mL			
(November - March)		--	--	2,000
(April - October)		--	--	200

(1) A minimum removal efficiency of 85% is required also for these parameters.

(2) Whole Effluent Toxicity (WET) testing is also required on an annual basis, as well as a Priority Pollutant Scan once between January 1, 2009 and June 30, 2009.

(3) Measured as a Monthly Geometric Average.

Table 2 KDHE Nitrogen and Phosphorus Treatment Limit Scenarios
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

Scenario	Total Nitrogen (TN) Limit (mg/L)	Total Phosphorus (TP) Limit (mg/L)	Basis for Limit
1	8.0	1.5	Biological Nutrient Removal (BNR)
2	5.0	0.5	Enhanced Nutrient Removal (ENR)
3	3.0	0.3	Limit of Technology (LOT)
4	0.7	0.4	Existing Water Quality
5	0.56	0.023	EPA Eco-Region Criteria

To establish the affordability of each scenario, the procedures for determining substantial and widespread impacts analysis presented in *EPA's Interim Economic Guidance for Water Quality Standards* were utilized. These procedures provide guidance on using economic factors to develop appropriate water quality standards and allow consideration of pollution sources, economics, and antidegradation in the evaluation process. The economic analysis included four main steps:

- Develop Annual Project Costs
- Perform Preliminary Screening
- Conduct Secondary Analysis
- Analyze Widespread Impacts

A summary of annual costs for the first three treatment limits scenarios (BNR, ENR, and LOT) are provided in Table 3.

Table 3 Treatment Limit Scenario Costs
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

	Treatment Limit Scenario		
Description	**BNR**	**ENR**	**LOT**
WWTP Upgrade and Expansion			
- Project Costs	$35.0	$49.5	$56.7
- O&M Costs (PW)	$8.5	$19.6	$24.4
Collection System Costs	$18.4	$18.4	$18.4
Total Net Present Worth	**$61.9**	**$87.5**	**$99.5**

Notes:

1. All costs are millions of dollars presented in 2008 dollars.
2. Project costs include estimated construction costs plus 20% engineering, legal, and administration contingency.
3. Present worth (PW) costs calculated based on interest rate of 6% and 20 year planning period.

In order to assess the burden that total pollution control costs are expected to have on existing households in Manhattan, an average annualized pollution control cost per existing household was calculated for all existing households in the community that would bear project costs. Table 4 summarizes the results and shows the existing cost per existing household, the additional cost per existing household, and the total cost per existing household.

Table 4	**Comparison of Annual Pollution Control Costs Per Existing Household WWTP Upgrade and Expansion Project City of Manhattan, Kansas**		
	Treatment Limit Scenario		
Description	**BNR**	**ENR**	**LOT**
Annual Pollution Control Cost Per Existing Household			
- Existing	$240	$240	$240
- Additional From Proposed Projects	$425	$590	$665
- Total	**$665**	**$830**	**$905**

With the estimate of total annual project costs complete, these costs were then compared to the median annual household income in Manhattan using the Municipal Preliminary Screening Test. This test estimates the total annual pollution control costs per household (existing costs plus those attributable to all anticipated wastewater system costs during the planning period) as a percentage of median household income. The screener is written as:

$$\text{Municipal Preliminary Screener} = \frac{\text{Annual Pollution Control Cost Per Existing Household}}{\text{Median Annual Household Income}}$$

Depending on the results of the screener, the community can be expected to incur little, mid-range, or large economic impacts due to the proposed project. If the municipal preliminary screener is less than 1 percent, then the project is not expected to impose a substantial economic hardship on households. However, if the municipal preliminary screener is greater than 2 percent, then the project would be expected to have a large economic impact and would impose an unreasonable financial burden on many of the households within the community.

Using the values from Table 4 with an estimated median annual household income in Manhattan of $37,900, the Municipal Preliminary Screener has values of 1.7%, 2.2%, and 2.4% for the BNR, ENR, and LOT options, respectively. Based on this screener, the BNR treatment limit scenario is expected to have a mid-range economic impact while the ENR and LOT treatment limit scenarios are expected to have large economic impacts.

Consideration must also be given to the community's ability to obtain financing and describes the socioeconomic health of the community. This Secondary Test involves establishing a secondary score based on the following factors:

- Bond Rating
- Overall Net Debt
- Unemployment
- Median Household Income
- Property Tax Revenues
- Property Tax Collection Rate

Based on values provided by the City for each of the categories, the Secondary Score for the City is approximately 2.5.

Using the results from the Municipal Preliminary Screener and the Secondary Score, a determination can made as to whether or not the community is expected to incur substantial impacts due to the proposed pollution control project. Based on the guidance provided in *EPA's Interim Economic Guidance for Water Quality Standards,* the City would incur substantial impacts as a result of implementing pollution control projects to meet the ENR and LOT treatment limit scenarios and are therefore not required. However, the BNR treatment limit scenario does not create a substantial impact and must therefore be provided to protect water quality.

Based on discussions with KDHE and the proposed WWTP expansion, it is expected that the next NPDES permit to be in March 2010 will include a compliance schedule for implementing nutrient removal and require that various nutrient constituents in the effluent be monitored.

1.5 PROCESS EVALUATION AND SELECTION

To complete the analysis required by KDHE, the evaluation and selection of appropriate wastewater treatment technologies is required. While there are a number of treatment alternatives available that could meet the treatment limits, not all were considered to be appropriate for the City's treatment plant and its unique wastewater characteristics. The following were determined to be key criteria in the treatment selection process:

- Proven Process Performance
- Operator Friendly
- Optimizes Energy and Chemical Usage
- Compatible with Existing Processes
- Minimizes Operational Impacts During Construction
- Expandable to ENR/LOT Limits
- Cost Effective

Using these criteria, an extensive list of potential treatment alternatives was reviewed to develop a "short-list" of alternatives to be considered for a more detailed evaluation, including the preparation of conceptual process designs and cost estimates. These five "short-listed" alternatives are as follows:

- Johannesburg (JHB) Process
- Modified Ludzak-Ettinger (MLE) Process with Metal Salt Addition
- Biological Aerated Filters (BAFs) and Denitrification Filters (DNFs)
- Integrated Fixed-Film Activated Sludge (IFAS)
- Membrane Biological Reactors (MBRs)

Design criteria were established for each of these alternatives based on an analysis of historical operating data, KDHE requirements, experience, and commonly accepted design standards. Using these design criteria, conceptual process designs were developed using desktop simulation software and used as the basis for preliminary cost estimates. A cost comparison of the alternatives is presented in Table 5.

Table 5 Construction Cost Comparison
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

Process	Cost [1]
Johannesburg (JHB) Process	$29.2
Modified Ludzak-Ettinger (MLE) Process with Metal Salt Addition	$30.3
Biological Aerated Filters (BAFs) and Denitrification Filters (DNFs)	$36.2
Integrated Fixed-Film Activated Sludge (IFAS)	$30.3
Membrane Biological Reactors (MBRs)	$33.9

Notes:

1. Includes costs for various facilities common to each option.

Based on the values presented in Table 5, the Johannesburg (JHB) process was determined to be the lowest overall cost alternative. Additional detailed evaluation using dynamic process modeling tools confirmed process performance. Therefore, development of the JHB process as shown in Figure 6, is recommended as the best solution for meeting the process goals for the Manhattan WWTP.

1.6 RECOMMENDED UPGRADES AND IMPROVEMENTS

The recommended nutrient removal treatment approach using the JHB process requires that a number of new unit processes be constructed, including a new selector basin, new aeration basins, a new mixed liquor recirculation pump station, new splitter structures, additions to the plant electrical system, and associated sitework / yard piping. To accommodate the new plant hydraulic gradeline for the JHB process, improvements to upstream processes such as influent pumping and grit handling will be required. A fourth influent pump will be required to obtain the required firm pumping capacity. And while the existing grit facility could potentially be modified to accommodate the new plant hydraulic gradeline, the poor performance of a process/facility at the end of its useful life makes this a good candidate for replacement with a new grit handling facility.

Some of the improvements noted previously, such as new aeration basins, new blower building, and additions to the plant electrical system, are also required to provide the necessary increase in plant capacity. Other process elements needed to address plant expansion include new final basins (clarifiers).

There are also a number of improvements needed to address processes/equipment that are minimally or non-functional, have low reliability, or are nearing the end of their useful life. For example, spare parts for the UV disinfection system are becoming increasingly difficult to obtain because the original equipment manufacturer sold their product line and therefore requires replacement of the UV system with a current technology that can be supported by the manufacturer. The effluent flow meter also needs to be replaced because the equipment and/or installation does not allow for accurate flow measurement. Accurate flow measurement is required to allow the UV disinfection system to be flow-paced and operate at optimum efficiency. Upgrades are also required to the main plant electrical switchgear as this switchgear is nearing the end of its useful life, is limiting plant reliability, and represents a safety hazard for plant personnel.

A cost distribution presented in Table 6 shows how the various construction costs are allocated between improvements needed to meet regulatory requirements, those needed to provide for expansion, and those needed for replacement of existing processes/equipment. This table shows that nearly 50% of the project costs can be attributed to unfunded regulatory mandates.

Table 6 Construction Cost Distribution
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

Description	Regulatory	Expansion	Replacement	Total
Preliminary Treatment	$0.0	$0.3	$2.4	$2.7
Secondary Treatment	$10.4	$5.1	$0.6	$16.1
Disinfection Improvements	$0.0	$0.1	$0.5	$0.6
Electrical Improvements	$0.8	$1.0	$1.9	$3.7
Sitework / Yard Piping	$1.9	$1.9	$0.0	$3.8
Peak Flow Holding	$1.0	$1.0	$0.0	$2.0
Miscellaneous Improvements	$0.0	$0.0	$0.3	$0.3
Total	**$14.1**	**$9.4**	**$5.7**	**$29.2**
	48%	32%	20%	

Notes:

1. All costs are millions of dollars presented in 2008 dollars.

1.7 PROJECT FINANCING

Many municipal capital improvements are funded by the issuance of debt in the form of bonds. This project will be funded by revenue bonds with the debt being retired by user fees. Financial assistance through the State Revolving Fund (SRF) may not be available.

1.8 PROJECT SCHEDULE

The anticipated project schedule is presented in Table 7.

Table 7 Project Schedule
WWTP Upgrade and Expansion Project
City of Manhattan, Kansas

Milestone	Date
Complete Preliminary Design Report	June 2008
Begin Final Design	July 2008
Complete Final Design	March 2009
Receive KDHE Approval (1)	June 2009
Begin Construction (2)	October 2009
Complete Construction (3)	March 2012

Notes:

1. Assumes 3-month review period by KDHE.
2. Assumes 3-month bidding and award period after KDHE approval.
3. Based on 30-month construction schedule.

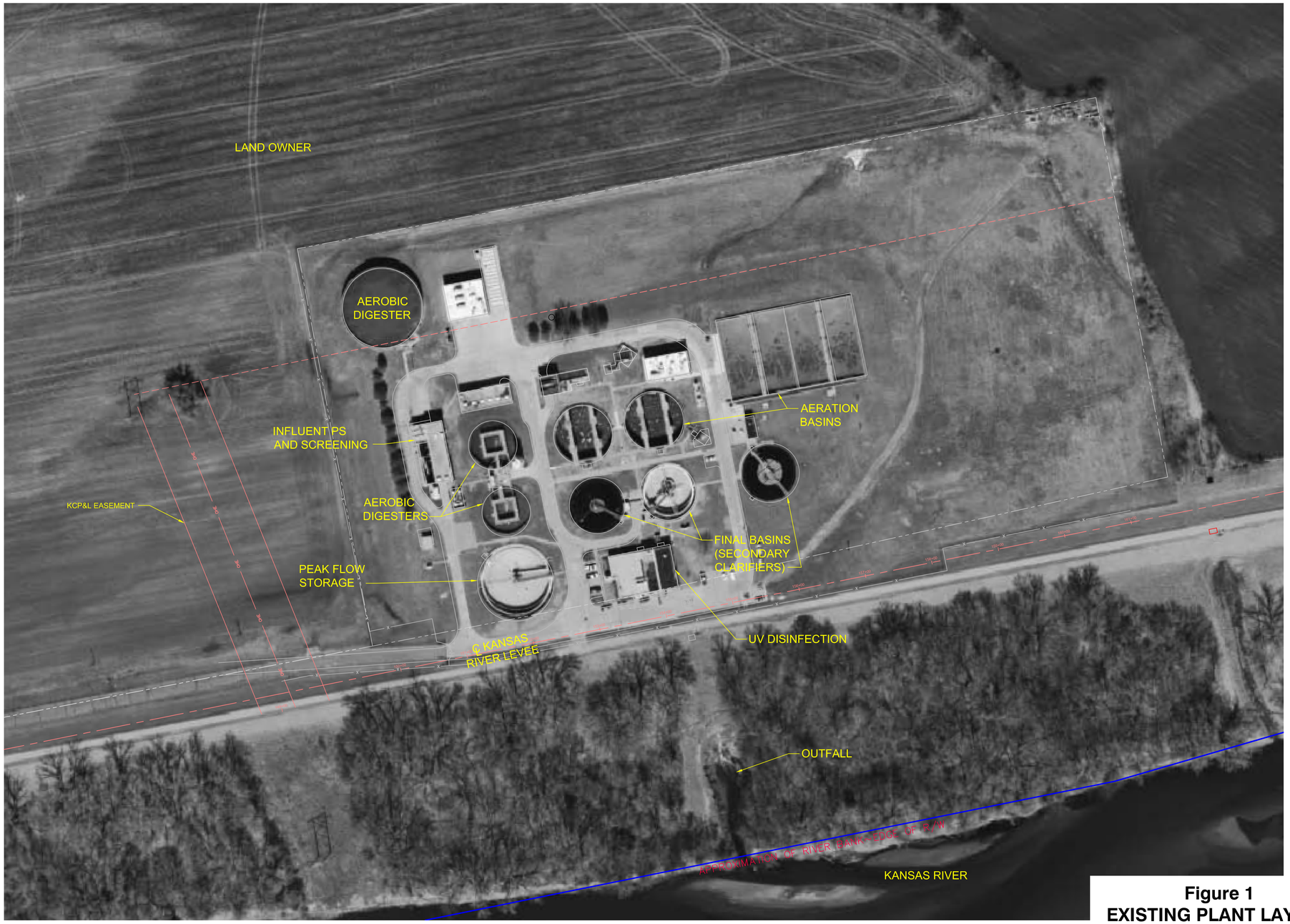
1.9 FUTURE NON-RESIDENTIAL CONTRIBUTIONS

Manhattan is one of five sites currently under consideration for construction of the National Bio and Agro-Defense Facility (NBAF). This proposed facility is anticipated to use alkaline tissue digestion processes for carcass disposal similar those processes currently used by the College of Veterinary Medicine (Vet Med) and the Biosecurity Research Institute (BRI). While the existing high-strength wastewater contributions from Vet Med and BRI represent a minor component of the total loading to the WWTP, the wastewater contribution from the NBAF would be significantly larger and would represent a significant component of the total loading to the plant. To accommodate this increased loading, additional improvements would be required either at the WWTP or at pretreatment facilities located at or near the proposed NBAF location.

NORTH

0 40' 80' 160'

NOTE:
EXISTING SITE PLAN MODIFIED FROM OCTOBER 2004 CH2MHILL SHEET 9, DRAWING C-1. EXISTING STRUCTURE SIZES AND LOCATIONS ARE APPROXIMATE.



LEGEND:
EXISTING FACILITIES

Figure 1
EXISTING PLANT LAYOUT
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

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Last Saved By: TAS 5-07-08 07:36am
C:\pw_working\projectwise\ccantrell\dms45233\Existing Plant Layout 5-07-08 04:08pm CCantrell XREFS: Fig Background Manhattan Aerial Photo; CH2MHILL Site-Yard Piping Plan.tiff; Manhattan Aerial Photo;

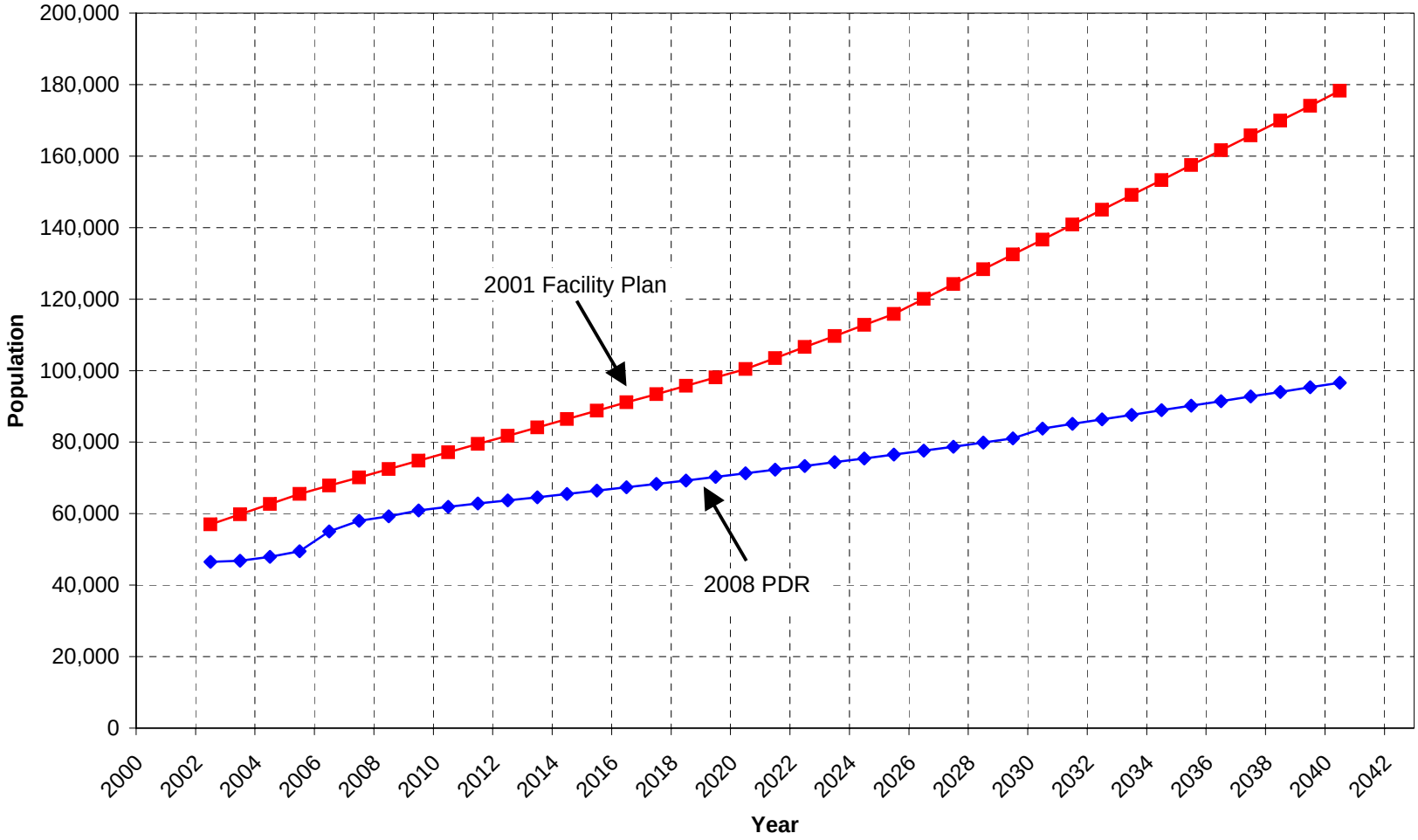


FIGURE 2
POPULATION PROJECTION COMPARISON
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

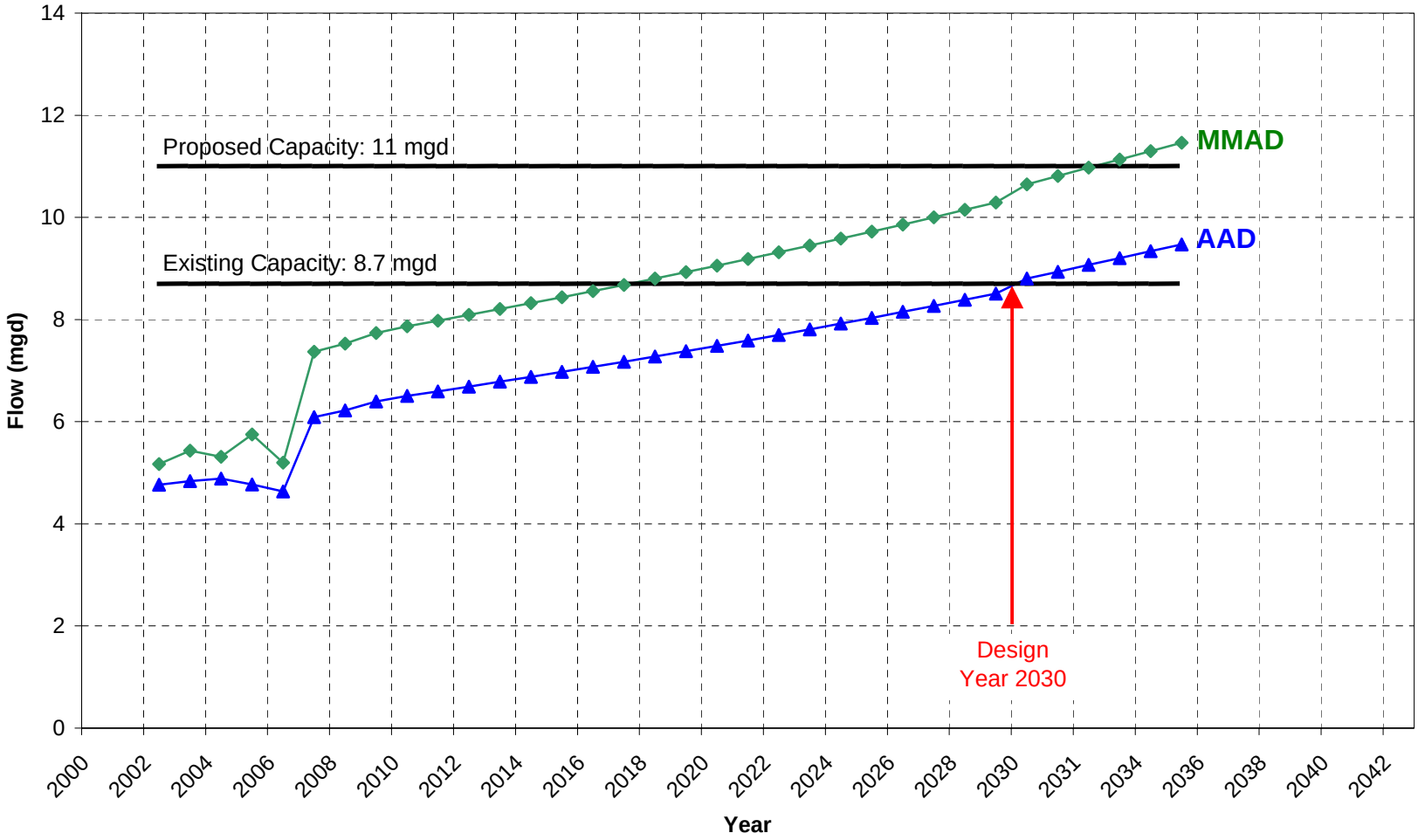


FIGURE 3
FLOW PROJECTIONS
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

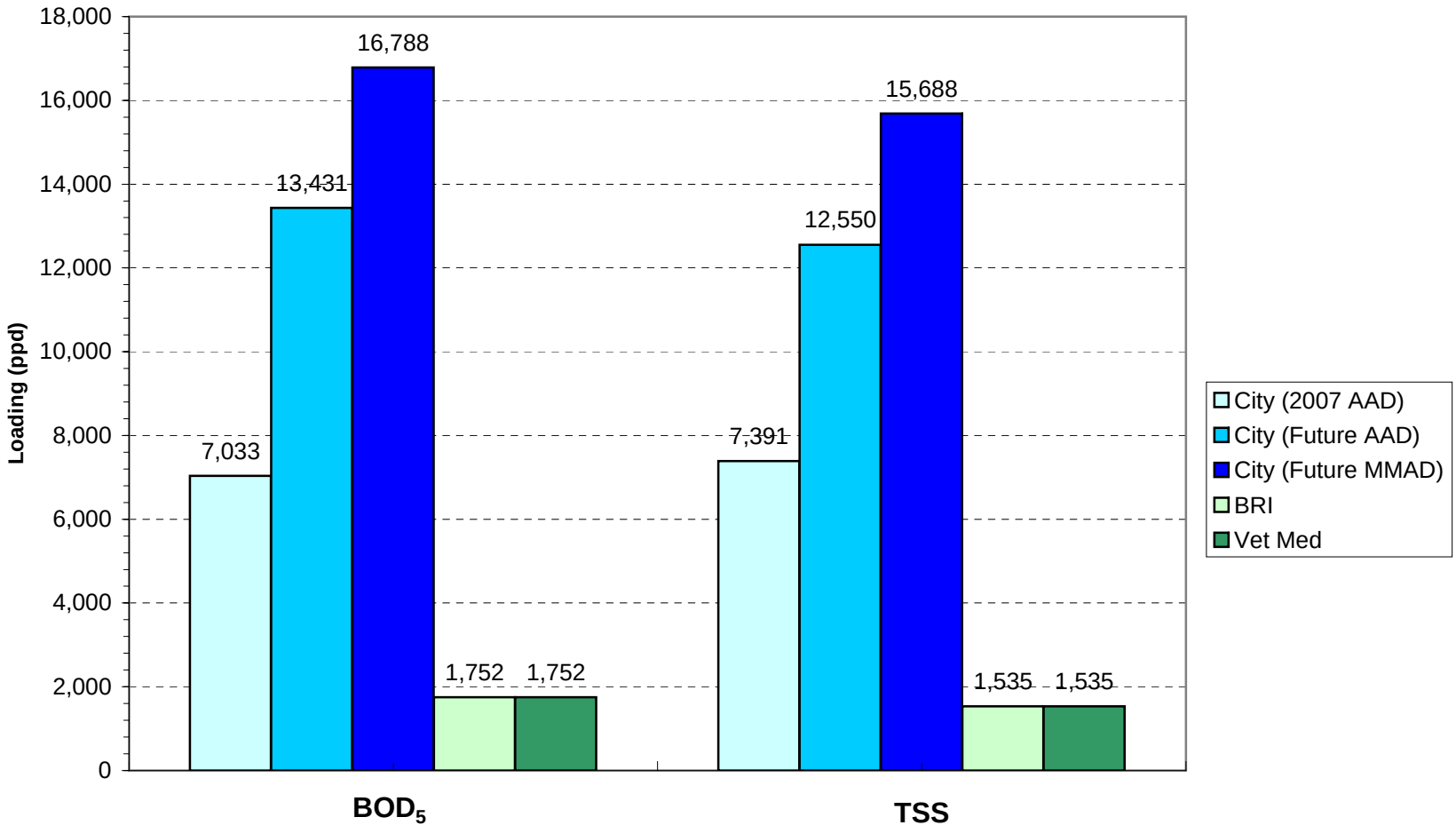


FIGURE 4
WASTEWATER CHARACTERISTICS: BOD_5 AND TSS
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

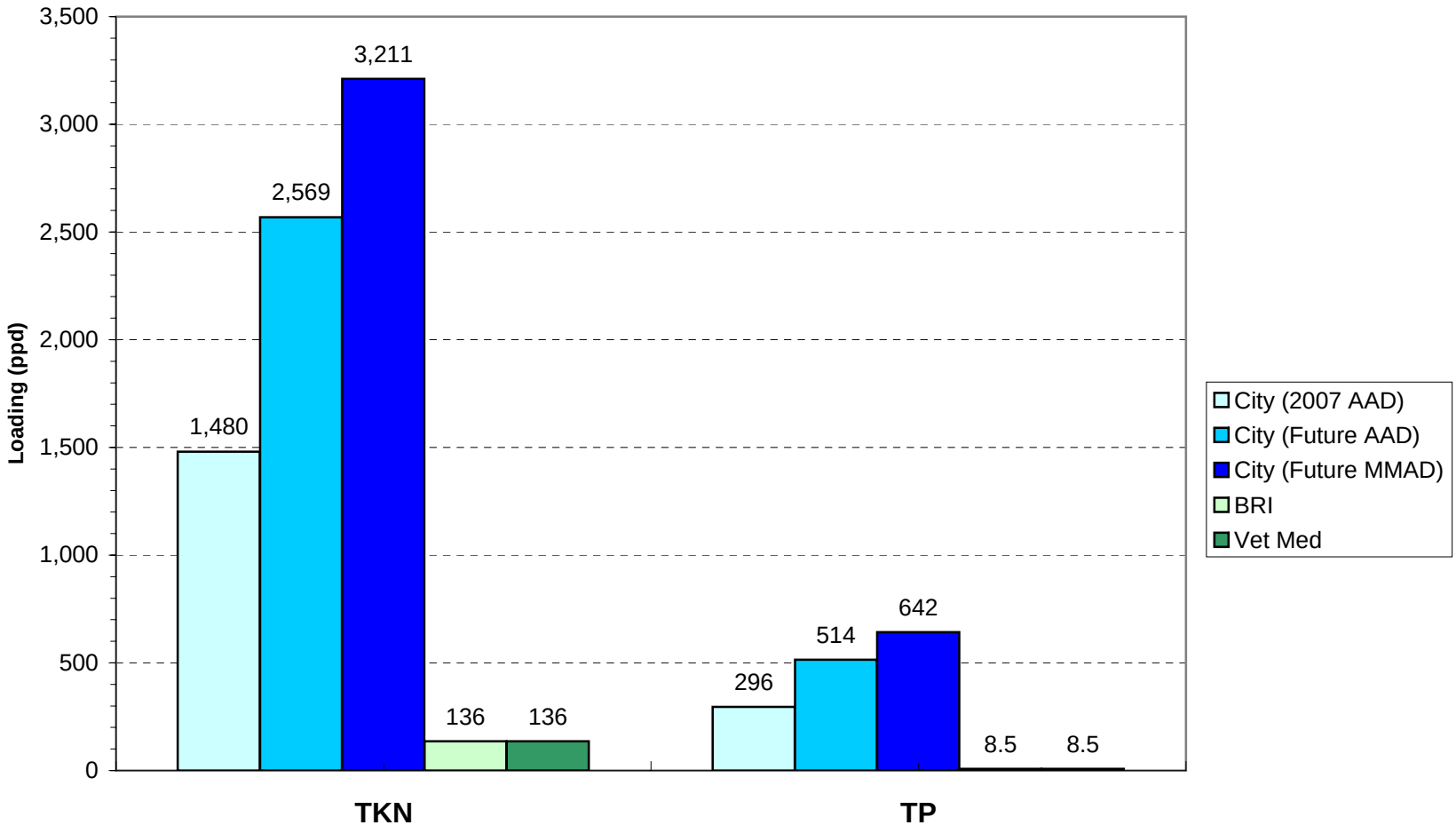
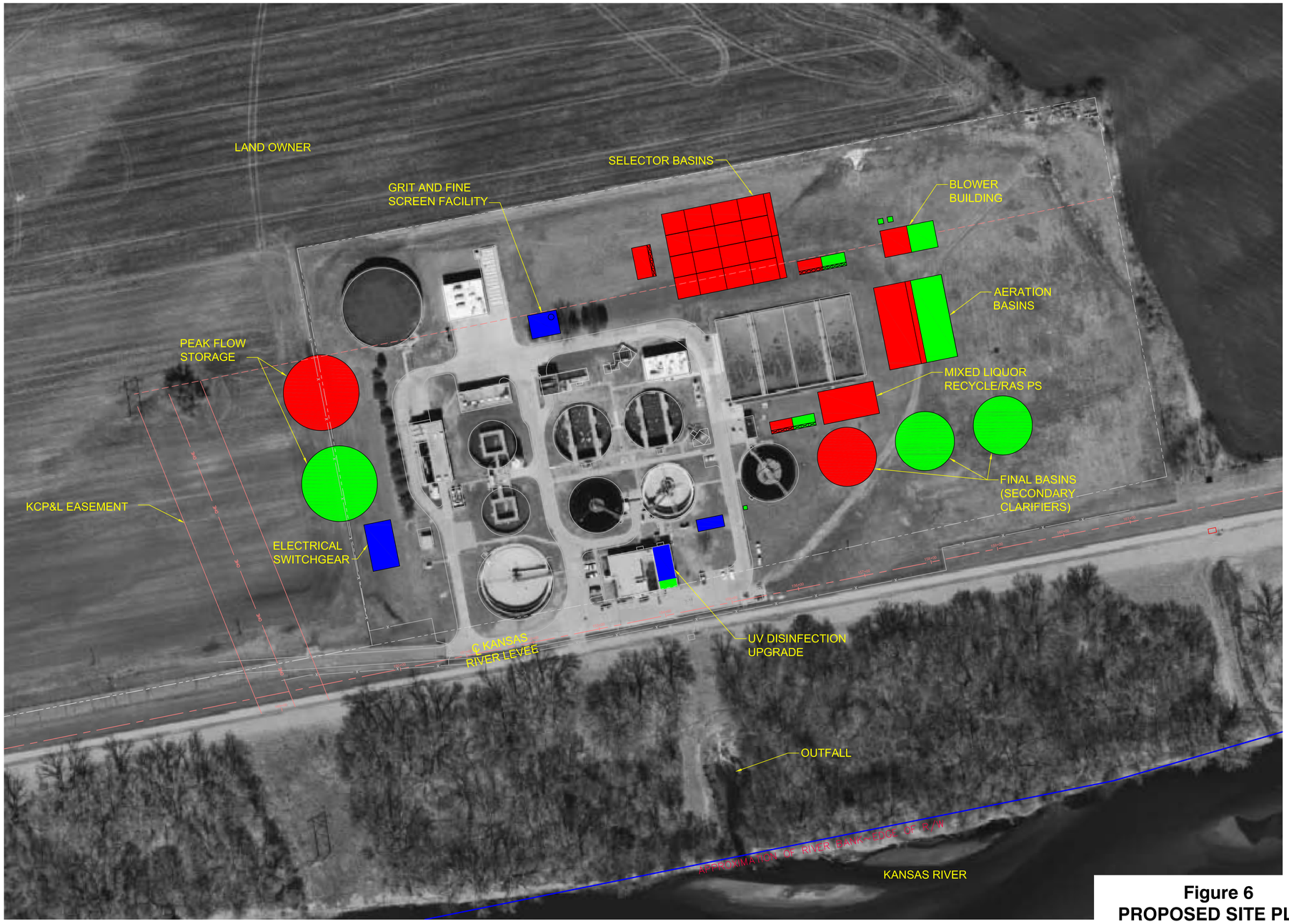


FIGURE 5
WASTEWATER CHARACTERISTICS: NITROGEN AND PHOSPORUS
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

NORTH

0 40' 80' 160'

NOTE:
EXISTING SITE PLAN MODIFIED FROM OCTOBER 2004 CH2MHILL SHEET 9, DRAWING C-1. EXISTING STRUCTURE SIZES AND LOCATIONS ARE APPROXIMATE.



LEGEND:

EXISTING FACILITIES — REGULATORY — EXPANSION — REPLACEMENT

Figure 6
PROPOSED SITE PLAN
WWTP UPGRADE AND EXPANSION PROJECT
CITY OF MANHATTAN, KANSAS

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