Columbia Wastewater and Stormwater IMP

Attachment G

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Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 3
Wastewater Treatment System Evaluation

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
February 2, 2017

HDR

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Shockey Consulting Services, llc
TREKK DESIGN GROUP, LLC

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Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's wastewater and stormwater utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

A critical step in the IMP includes evaluating the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. This evaluation is important because it forms the basis for identifying priorities and developing alternatives in subsequent phases of the IMP. To develop a comprehensive understanding of existing conditions, the City and their project team compiled and evaluated existing surface water, wastewater, and stormwater data. These data, as well as current operation and maintenance practices and procedures, were then reviewed and discussed in a series of workshops. Results from these efforts are documented in the following technical memoranda:

- Technical Memorandum 1 – Surface Water Quality and Biological Conditions
- Technical Memroandum 2 – Wastewater Collection System Assessment
- Technical Memorandum 3 – Wastewater Treatment System Assessment
- Technical Memorandum 4 – Stormwater System Assessment

Wastewater treatment is an essential service provided by the City and is critical for protection of regional water quality. The Columbia Regional Wastewater Treatment Plant (CRWWTP) treats residential, commercial and industrial wastewater generated within the Columbia metropolitan area and is one of the City's most significant infrastructure assets. The CRWWTP's ability to accommodate growth in the community and comply with current and future regulations are vital considerations for the City during the IMP development process. This evaluation summarizes the current CRWWTP capacity and performance to help inform planning decisions regarding plant upgrades that may be required to meet anticipated future growth and regulatory requirements.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington DC.

Section 2. CRWWTP and Effluent Discharge Description

The CRWWTP consists of a mechanical treatment plant (**Figure 1**) followed by a series of four treatment wetlands units for additional wastewater treatment (**Attachment A**). The treatment wetlands are a unique feature of the CRWWTP. Constructed treatment wetlands use natural physical, biological, and chemical processes to remove a wide array of wastewater pollutants, including organics, nutrients, ammonia, metals, and bacteria. Treated effluent from the CRWWTP is discharged into the Eagle Bluffs Conservation Area (Eagle Bluffs) to provide a valuable water source for wildlife habitat.

Since the CRWWTP was initially constructed in 1983, more than 100 small WWTPs have been eliminated in Columbia. The CRWWTP continues to be an important regional wastewater treatment provider in the area. Currently, there are 38 domestic and 8 industrial wastewater treatment plants in or near Columbia (see Technical Memorandum 1). Of the 38 domestic National Pollutant Discharge Elimination System (NPDES) permits, 11 are decommissioning and joining either the CRWWTP or Boone County Regional Sewer Districts systems.

Figure 1. Aerial View of the Columbia Regional Wastewater Treatment Plant.

2.1 Mechanical Treatment Plant

The mechanical plant is strategically located at the confluence of Hinkson and Perche Creeks to maximize the use of gravity flow through the wastewater collection system. Mechanical plant treatment processes include:

- flow equalization,
- screening,
- grit separation,
- primary clarification,
- activated sludge treatment with clarification,
- anaerobic digestion,
- primary sludge thickening,
- waste activated sludge thickening
- sludge dewatering, and
- biosolids land application.

Wastewater treated through the mechanical plant flows into the constructed wetlands for additional treatment before being discharged to Eagle Bluffs. Screenings and grit are landfilled. Biosolids generated by the mechanical plant are primarily land applied on nearby farmland as a soil amendment or sent to a landfill.

2.2 Constructed Treatment Wetlands

The constructed treatment wetlands provide additional treatment of mechanical plant effluent prior to discharge to Eagle Bluffs. The four constructed treatment wetlands units are positioned along Perche Creek to enable gravity flow of wastewater through the wetlands units. Wastewater flowing through the wetlands is treated through the biological, chemical and physical interactions of aquatic plants (primarily cattails), sunlight, and sediment micro-organisms. The treatment wetlands cover 130 acres, making this one of the largest constructed treatment wetlands used for municipal wastewater treatment in the country.

2.3 Discharge to Eagle Bluffs Conservation Area

Effluent from the CRWWTP is pumped more than two miles and is discharged into the Eagle Bluffs Conservation Area (Eagle Bluffs), a 4,400 acre wetland and wildlife area. CRWWTP effluent is the primary source of water for wetland habitat in the expansive Eagle Bluffs aquatic system (**Attachment B**). Eagle Bluffs is managed by the Missouri Department of Conservation (MDC). This cooperative arrangement between the City and MDC represents one of the Nation's most prominent projects reclaiming wastewater effluent for wildlife habitat creation.

Once CRWWTP effluent enters Eagle Bluffs, MDC directs the water to various channels and pools to achieve MDC's wildlife management objectives. Occasionally, water from Eagle Bluffs is discharged for short durations into an unnamed Missouri River slough, which drains into the Missouri River. During Missouri River flood conditions, MDC can also drain flood waters from Eagle Bluff's downstream pools into Perche Creek, which likewise discharges into the Missouri River.

2.5 Recent CRWWTP Upgrade

The Missouri Department of Natural Resources (MDNR) establishes effluent quality requirements through the CRWWTP's NPDES discharge permit. In 2009, MDNR established an average monthly limit of 6.0 milligrams per liter (mg/L) of ammonia expressed as nitrogen (ammonia) to meet water quality criteria in Eagle Bluffs and the Missouri River. The City upgraded the CRWWTP to meet this new effluent limit). The plant upgrade and expansion was completed in 2013, at a total cost of approximately $64 million.

The upgrade increased the capacity of the entire CRWWTP, including the constructed treatment wetlands, from a design average flow (DAF) of 20.6 million gallons per day (MGD) to 25.2 MGD. The upgrade included the addition of two new mechanical plant treatment trains (**Figure 2**). The original mechanical plant had a capacity of 12.6 MGD and consisted of two parallel treatment trains, each rated at 6.3 MGD. These two trains were not designed for biological ammonia removal (nitrification). Two new treatment trains, also rated for 6.3 MGD each, were added during the upgrade, effectively doubling the mechanical plant capacity. The new treatment trains are designed to fully nitrify year round. Additionally, the anoxic zones in the new treatment trains provide the opportunity to reclaim alkalinity and some level of denitrification.

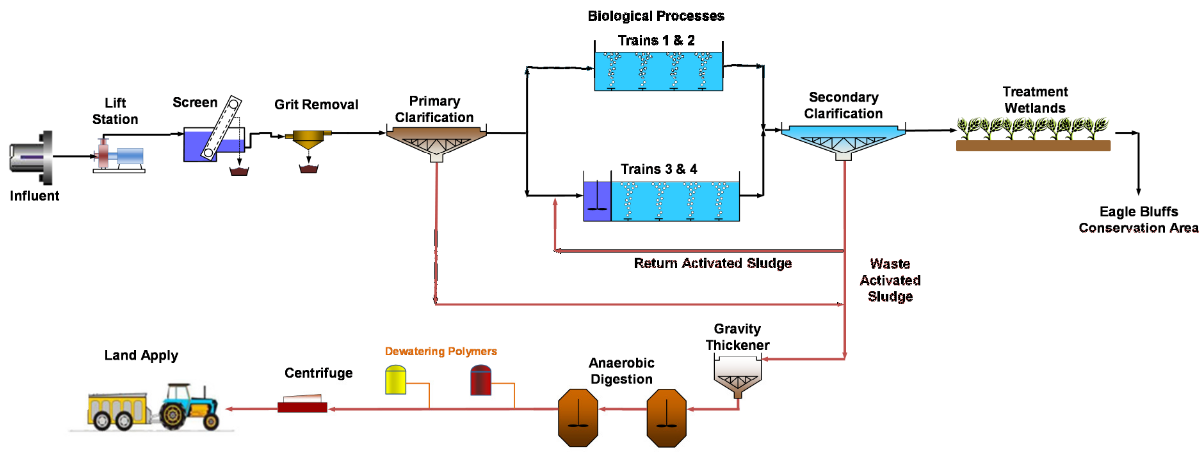

Figure 2. Process Flow Schematic of the Upgraded CRWWTP.

In addition to improvements and expansion of the secondary treatment trains, additional enhancements were made to the CRWWTP. These included upgrades to the headworks of the plant consisting of replacement of screening facilities and influent pumping units, wet well repairs, the construction of a grit removal facility and activated carbon odor control system. Upgrades to the solids handling portion of the treatment process included the construction of a biosolids dewatering facility, and construction of ferric chloride and polymer feed systems. Additional upgrades not related to the wastewater treatment system included a new potable water system, updates to site electrical systems, expansion of plant fire protection, the addition of natural gas to the site, road and perimeter security improvements, the construction of a new laboratory and administration building.

Section 3. CRWWTP Influent Loading

The first step in the performance evaluation was to compare average daily plant influent loading rates to design average loading rates for the recent plant upgrade. Average influent loading rates from 2007 through year-to-date (YTD) 2016 were selected to characterize actual influent loading. This date range includes five years of data before the upgrade and over three years of data following the upgrade.

Four influent parameters included in the evaluation were:

- Flow
- 5-day Biochemical Oxygen Demand (BOD_5)
- Total Suspended Solids (TSS)
- Ammonia

3.1 Influent Flow

CRWWTP annual daily average influent flow rates were well below the 25.2 MGD design average flow rate (**Figure 3**). The observed variation in the annual influent flow rates was likely due to variations in annual precipitation differences.

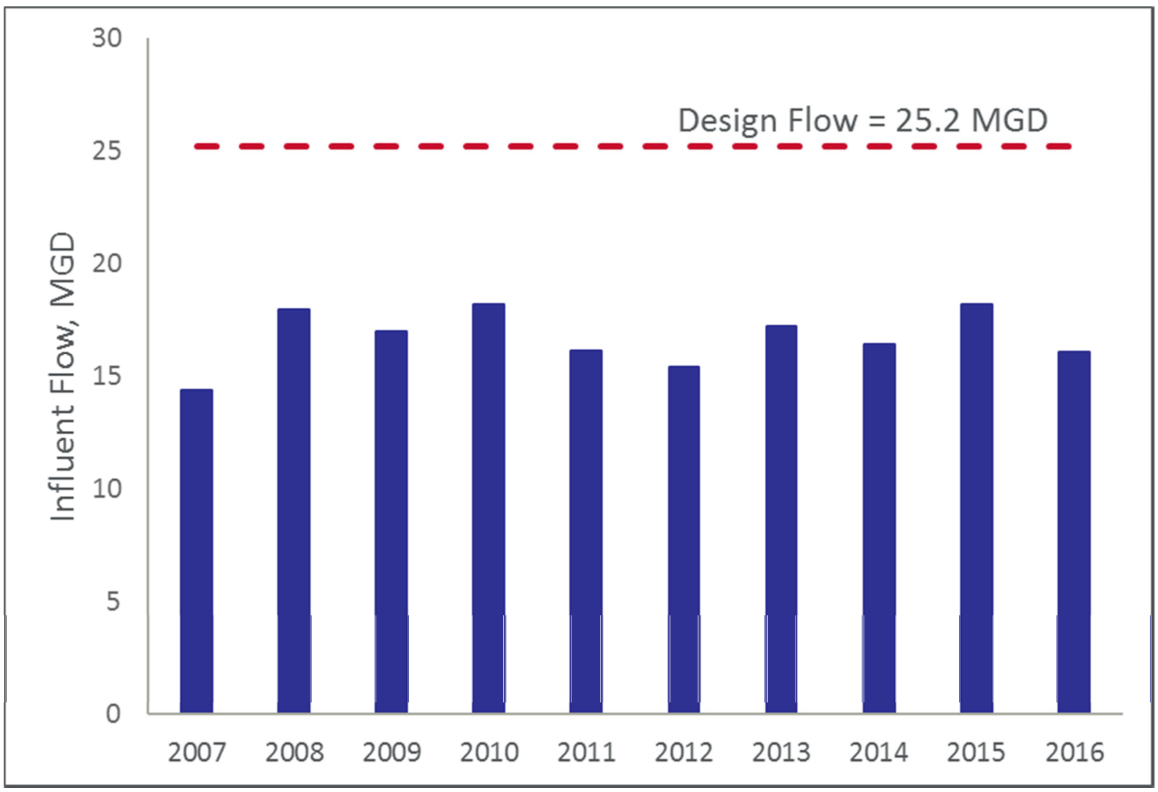

Figure 3. CRWWTP Annual Average Influent Flow 2007 through July 2016.

3.2 Influent Biochemical Oxygen Demand and Total Suspended Solids

Biochemical Oxygen Demand (BOD_5) is the measurement of the dissolved oxygen consumed by microorganisms in a water sample over a five-day period. BOD_5 is removed in the CRWWTP so that the effluent discharged from the plant will not create low dissolved oxygen conditions that may impact aquatic life downstream. TSS is a measurement of the quantity of suspended solid particles in a sample. TSS effluent limits are established to reduce the potential impacts of suspended solids on downstream aquatic life, habitat, and other biological and chemical characteristics.

CRWWTP BOD_5 and TSS loadings were evaluated based on mass loading, expressed as pounds per day (lbs/day). The influent sampling location for this data set includes the raw influent plus internal sidestream return loads. The annual average influent BOD_5 and TSS loadings from 2007 through July 2016 were approximately 40,400 lbs/day and 47,300 lbs/day, respectively. All annual average BOD5 and TSS loadings were below the design loading rates (**Figure 4, Figure 5**).

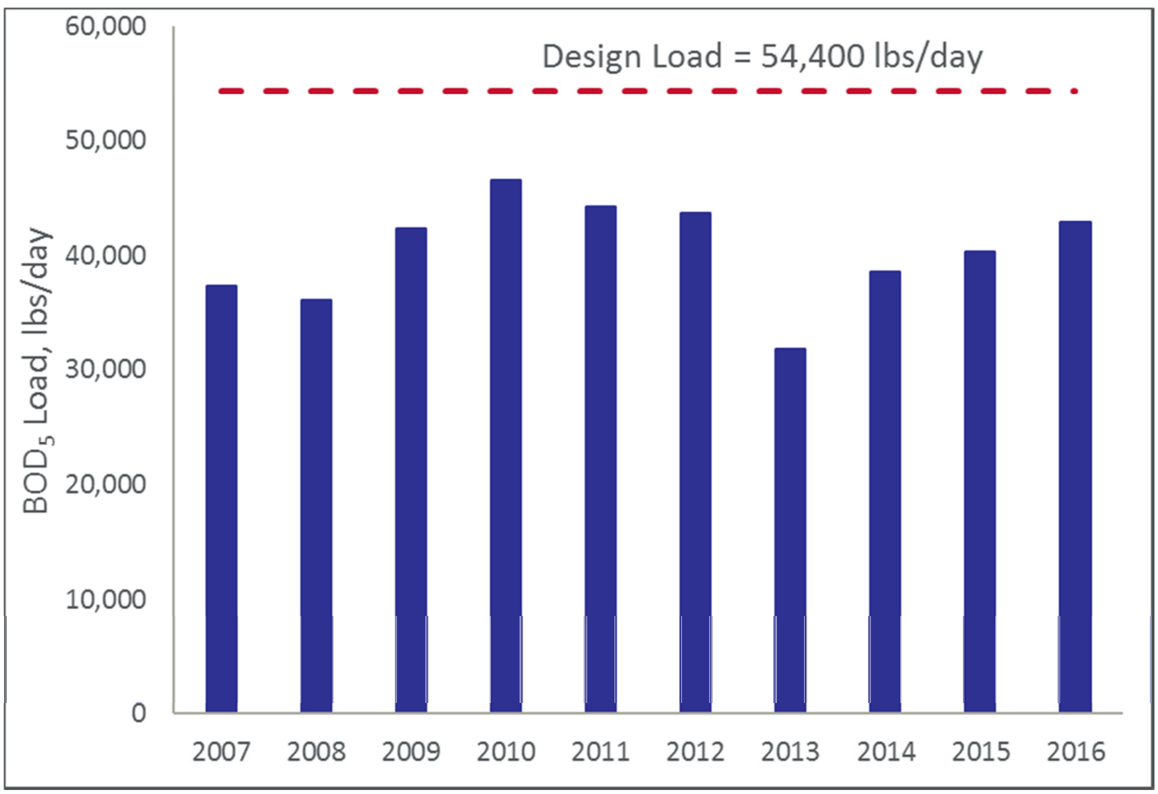

Figure 4. Actual Average Influent BOD_5 Load Compared to Design Influent BOD_5 Load.

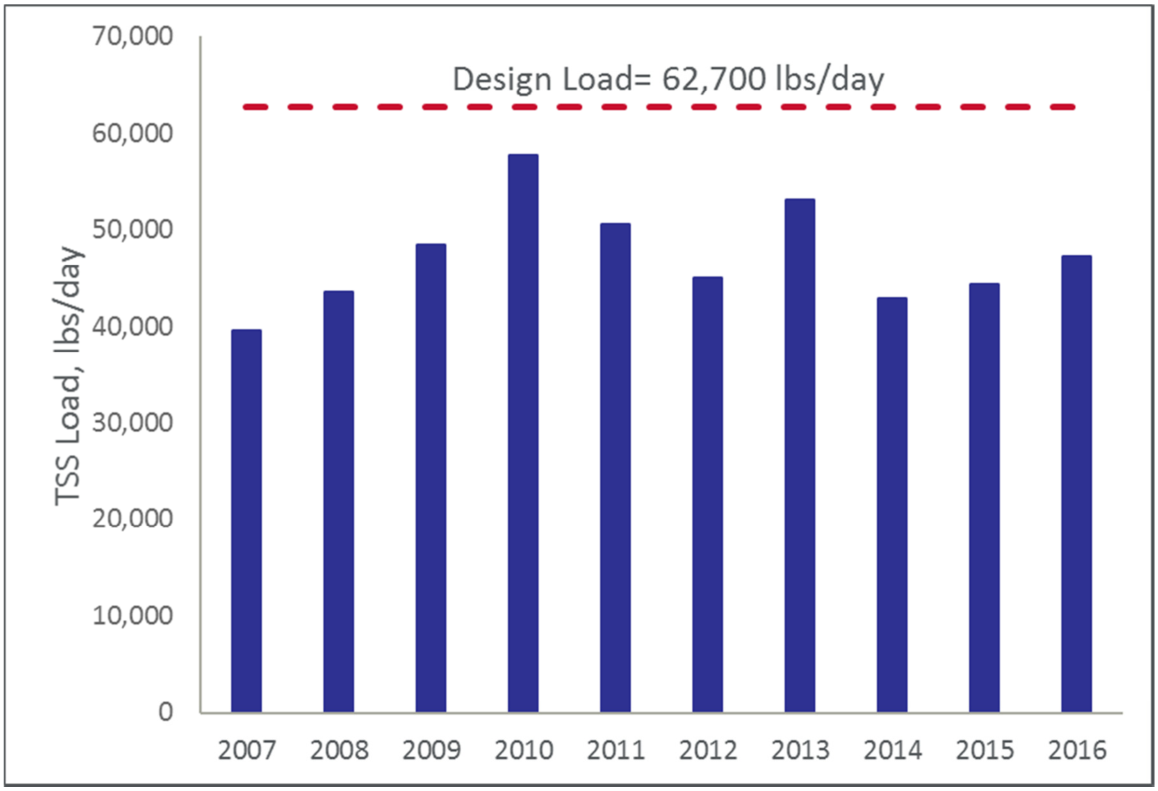

Figure 5. Actual Average Influent TSS load Compared to Design Influent TSS Load.

3.3 Influent Ammonia

Ammonia is present in domestic wastewater as a by-product of human digestion. In elevated concentrations, ammonia is toxic to aquatic life and can also contribute to dissolved oxygen depletion. As earlier described, the City upgraded the CRWWTP with the addition of two mechanical plant treatment trains that nitrify ammonia to meet the new ammonia permit limits required by MDNR and EPA.

3.3.1 Ammonia Design Effluent Limits and Treatment Trains

The CRWWTP upgrade was designed to meet an average monthly ammonia effluent limit of 6.0 mg/L ammonia at the design flow of 25.2 MGD by combining the effluent from the two existing trains that partially nitrify with effluent from the two new trains that fully nitrify. This combination should produce a typical effluent ammonia concentration below 1 mg/L (expressed as nitrogen). The original two treatment trains have enough volume and aeration capacity to support full nitrification at flows up to 2.2 MGD per basin. Therefore, the full nitrification capacity of the existing four trains is 17.0 MGD (6.3 MGD each from the two new trains and 2.2 MGD each from the two original trains. The current average flow is approximately 17 MGD, so the facility should be able to fully nitrify under current plant flow conditions.

3.3.2 Ammonia Loading and Trends

The average ammonia loading over the evaluation period was approximately 2,800 lbs/day; consistently below the influent design loading rate (with sidestream return flows) of 5,400 lbs/day. CRWWTP influent ammonia loadings have shown an upward trend (Figure 6Error!

Reference source not found.). The ammonia load has increased approximately 15 percent from 2012 to 2016. Approximately half of the increase can be attributed to sidestream contributions from the dewatering facilities constructed as part of the plant upgrade. The source of the remaining ammonia increase was not readily apparent. Ammonia data collected in the future will confirm if this upward trend continues and the whether the potential sources may be attributed to plant operational changes or influent loading from the collection system.

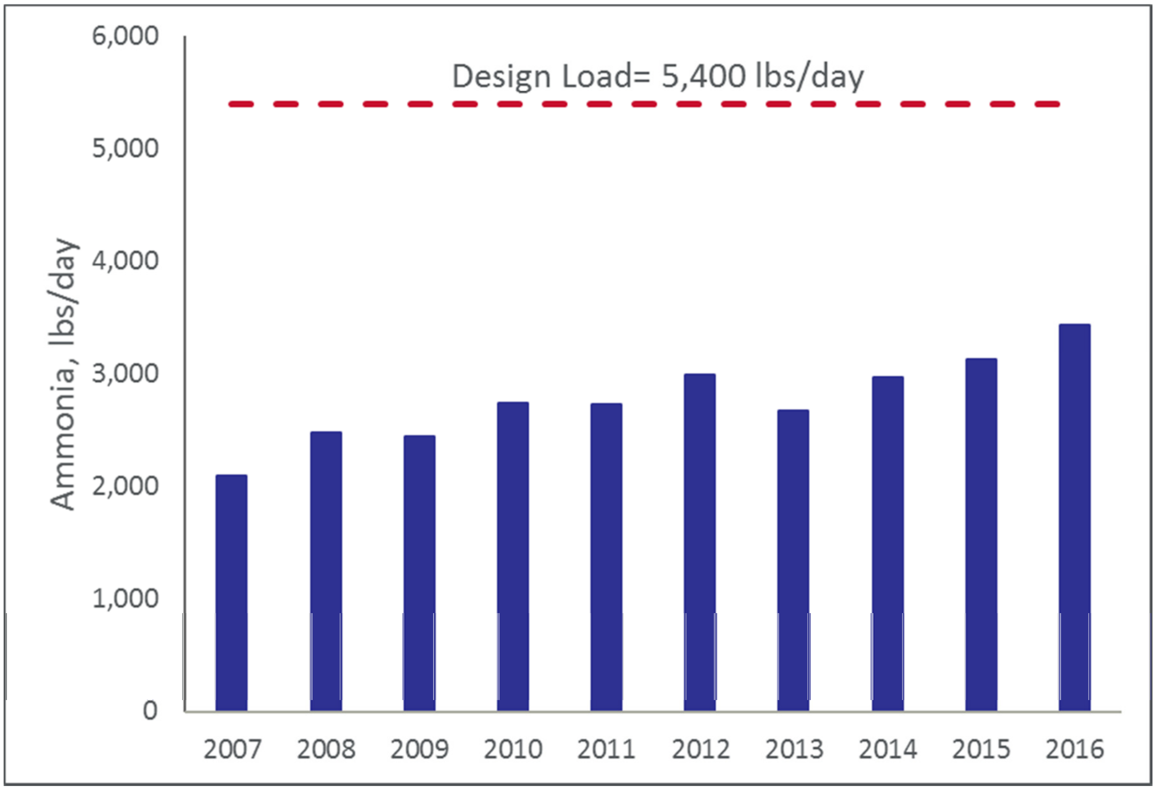

Figure 6. Actual Average Influent Ammonia Load.

Section 4. CRWWTP Treatment Performance

The performance of the CRWWTP was evaluated by comparing BOD_5, TSS and ammonia final effluent concentrations before and after the plant upgrade. The effluent concentrations were measured after the effluent had passed through the constructed treatment wetlands, at the wetlands pump station (WLPS). For each parameter, effluent concentrations are summarized in box and whisker plots[2] that compare the three years of concentration measurements prior to the plant upgrade (2007 through 2009) with effluent concentration measurements following the upgrade (2014 through YTD 2016). For each parameter, lower effluent concentrations indicate better treatment plant performance.

4.1 BOD_5 and TSS

The primary objective of the mechanical plant upgrade was to reduce effluent ammonia concentrations. Both effluent BOD_5 and TSS concentrations were satisfactory before the upgrade. However, these parameters were included in the post-upgrade evaluation to identify potential changes or trends. CRWWTP effluent BOD_5 concentrations decreased following the plant upgrade (**Figure 7**), with an average decrease of approximately 30 percent. CRWWTP effluent TSS concentrations (**Figure 8**), although slightly higher in 2016 (through July) measurements, remained consistent during the evaluation period.

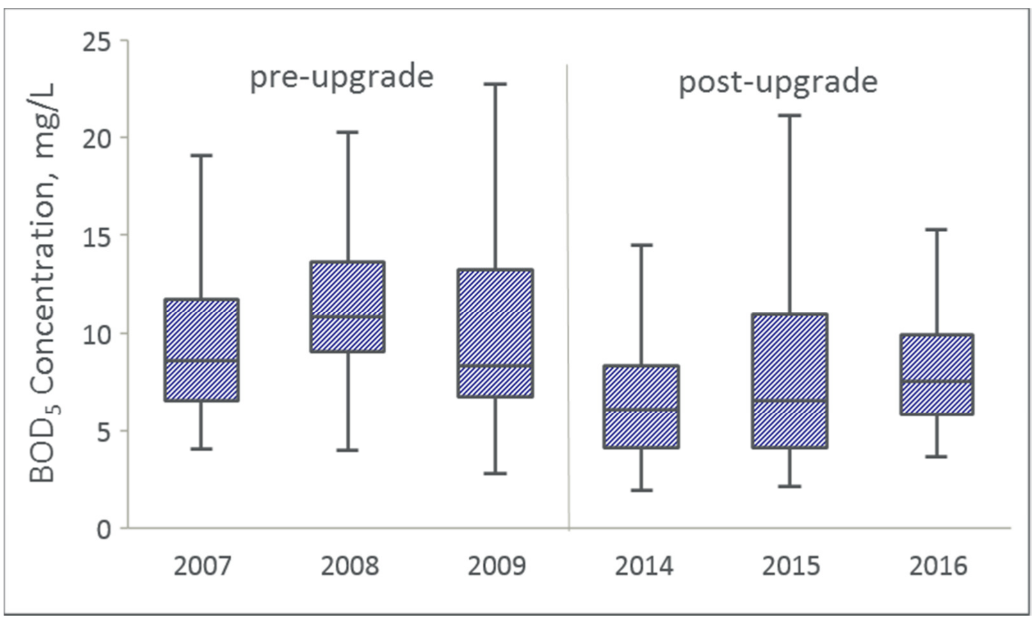

Figure 7. WLPS Effluent BOD_5 Concentration before and After the CRWWTP Upgrade.

[2] Boxes represent 25 to 75 percent of the results in a given year. The median result is displayed as a line in the box and the ends of the whiskers represent the maximum and minimum values, excluding statistical outliers.

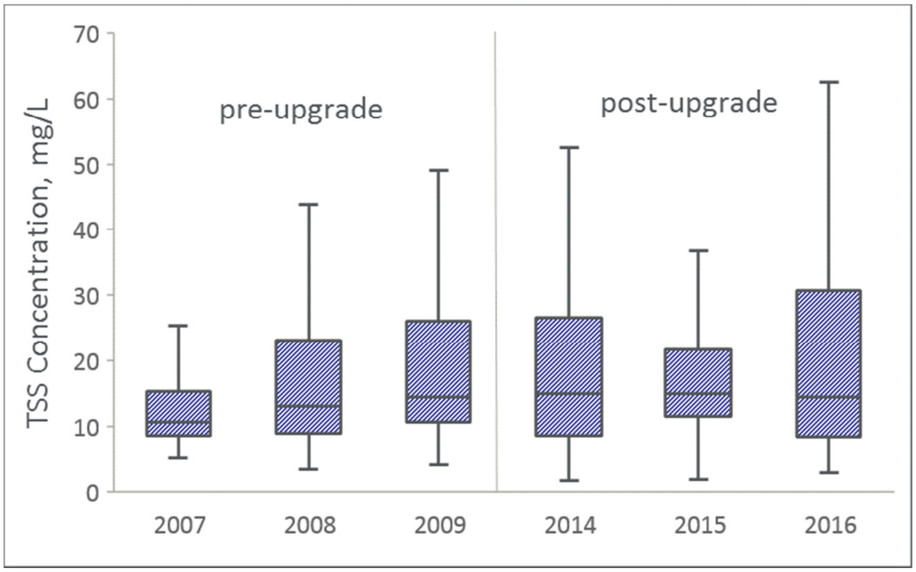

Figure 8. WLPS Effluent TSS Concentration before and After the CRWWTP Plant Upgrade.

4.2 Ammonia

As expected, effluent ammonia concentrations decreased appreciably following the plant upgrade (**Figure 9**). The median (50th percentile) pre-upgrade ammonia concentration was 14 mg/L and the median post-upgrade ammonia concentration was 1.7 mg/L, indicating an 88 percent reduction. With the exception of intermittent excursions during the upgrade startup period, CRWWTP effluent ammonia concentrations were consistently well below the draft 6.0 mg/L design monthly average, indicating that the primary objective of the plant upgrade had been achieved.

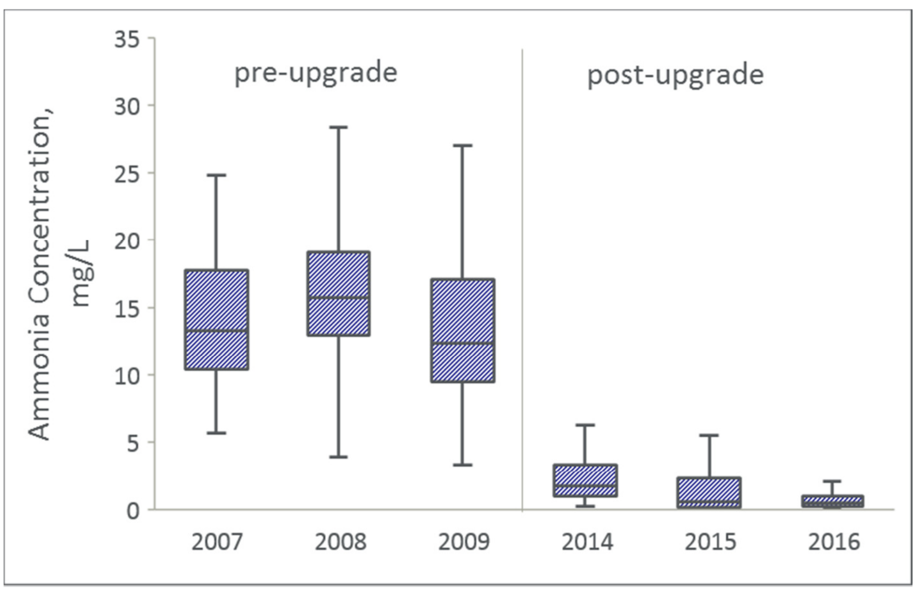

Figure 9. WLPS Effluent Ammonia Loading Before and After the CRWWTP Upgrade.

Section 5. Permit Limits Compliance

The CRWWTP's ability to comply with current NDPES discharge permit limits is an important consideration in the IMP process. To assess compliance, permit limit exceedances over a five-year period (2010 through 2014) were identified for all parameters with current numeric permit limits. This time period coincided with the compliance assessment included in the City's most recent NPDES permit application. With the exceptions of TSS and infrequent exceedances of metals, the CRWWTP consistently complied with effluent limits.

5.1 TSS Excursions due to Waterfowl

Large numbers of waterfowl overwinter on the constructed treatment wetlands and neighboring Eagle Bluffs wetlands. These birds agitate sediments in the wetlands, causing elevated TSS concentrations that occasionally exceed permitted TSS limits (**Figure 10, Figure 11**). During months with TSS excursions, MDNR requires the City to submit documentation of heavy waterfowl use. With this documentation submitted, the City if in compliance with permit limits and conditions. Based on recent MDNR correspondence, the next permit renewal will include more relaxed average weekly (AWL) and average monthly (AML) TSS limits during periods of heavy waterfowl.

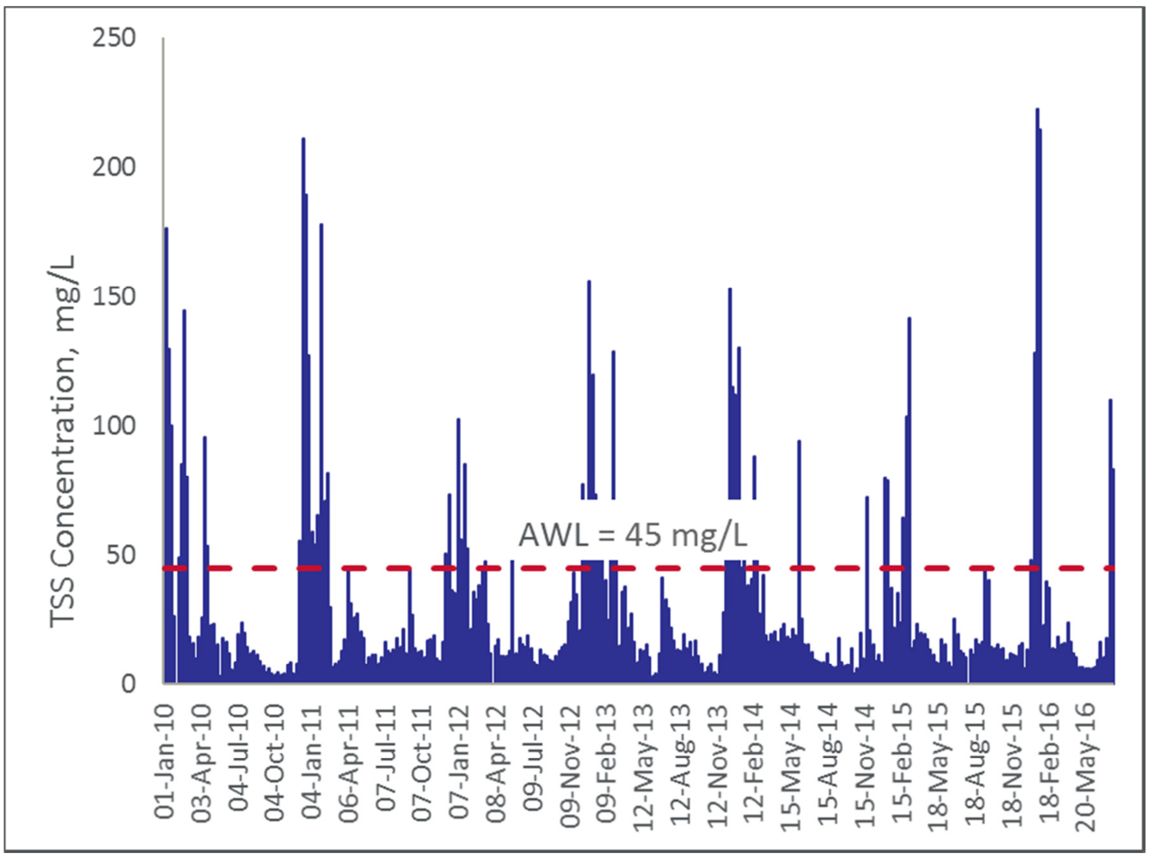

Figure 10. WLPS Effluent Weekly Average TSS Concentrations.

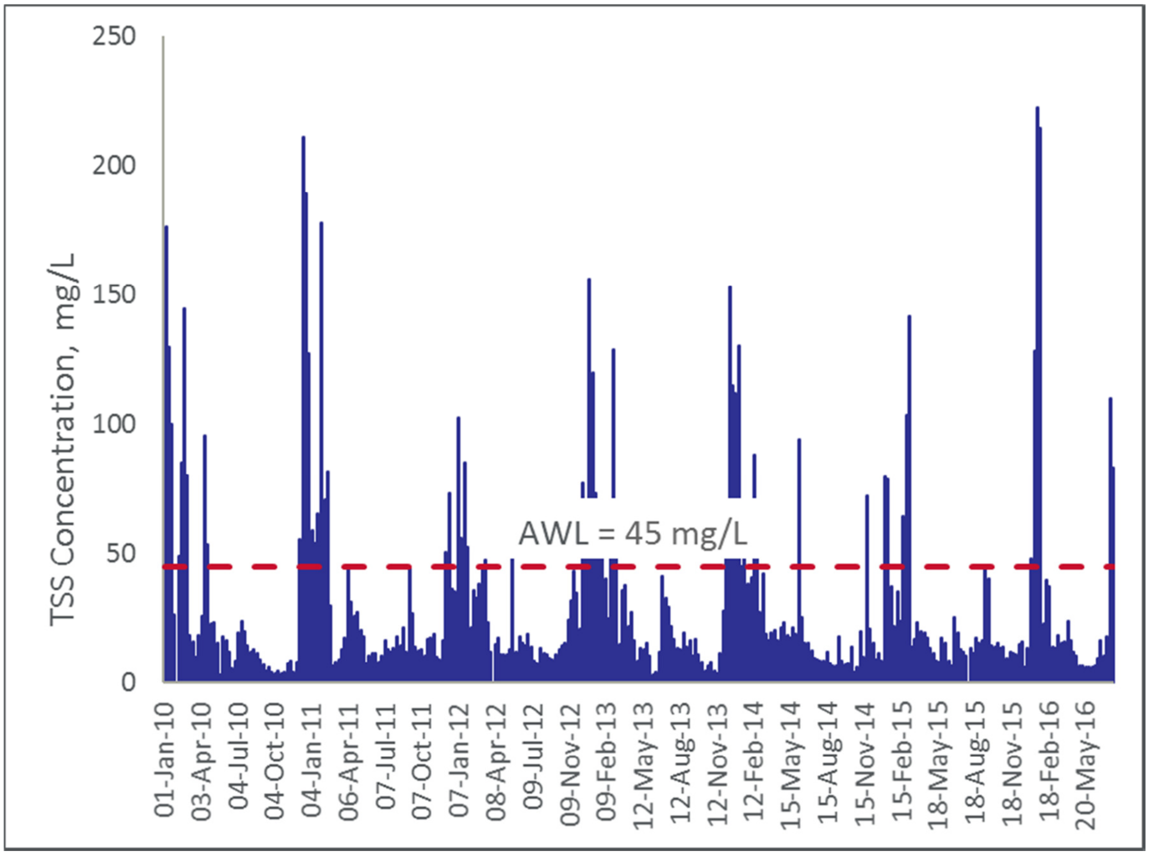

Figure 11. WLPS Effluent Monthly Average TSS Concentrations.

5.2 Compliance with Secondary Treatment BOD_5 and TSS Removal Requirement

Consistent with federal regulations dictating secondary treatment performance, the CRWWTP NPDES permit requires that the treatment plant remove 85% of the BOD_5 and TSS that enters the plant, as determined based on monthly average concentrations. The CRWWTP consistently meets this requirement aside from months of elevated TSS associated with heavy waterfowl activity on the constructed treatment wetlands.

5.3 Compliance with Whole Effluent Toxicity Testing

The CRWWTP NPDES permit also requires the City conduct an acute whole effluent toxicity (WET) test annually. The acute WET test measures the survival rate of test organisms placed in effluent samples for a 48-hour period. All WET tests conducted on CRWWTP effluent during the evaluation period passed, showing absence of acute toxicity.

5.4 Preliminary Bacteria Measurements

Although not required in the current CRWWTP permit, the City has proactively measured bacteria concentrations in both the mechanical plant and final effluents. The bacteria measurements show that, following the plant upgrade, the combination of the mechanical plant and the constructed treatment wetlands reduce bacteria to levels that, on average, are below the secondary contact recreation criterion, which may be applicable to EBCA in the future (**Figure 12**).

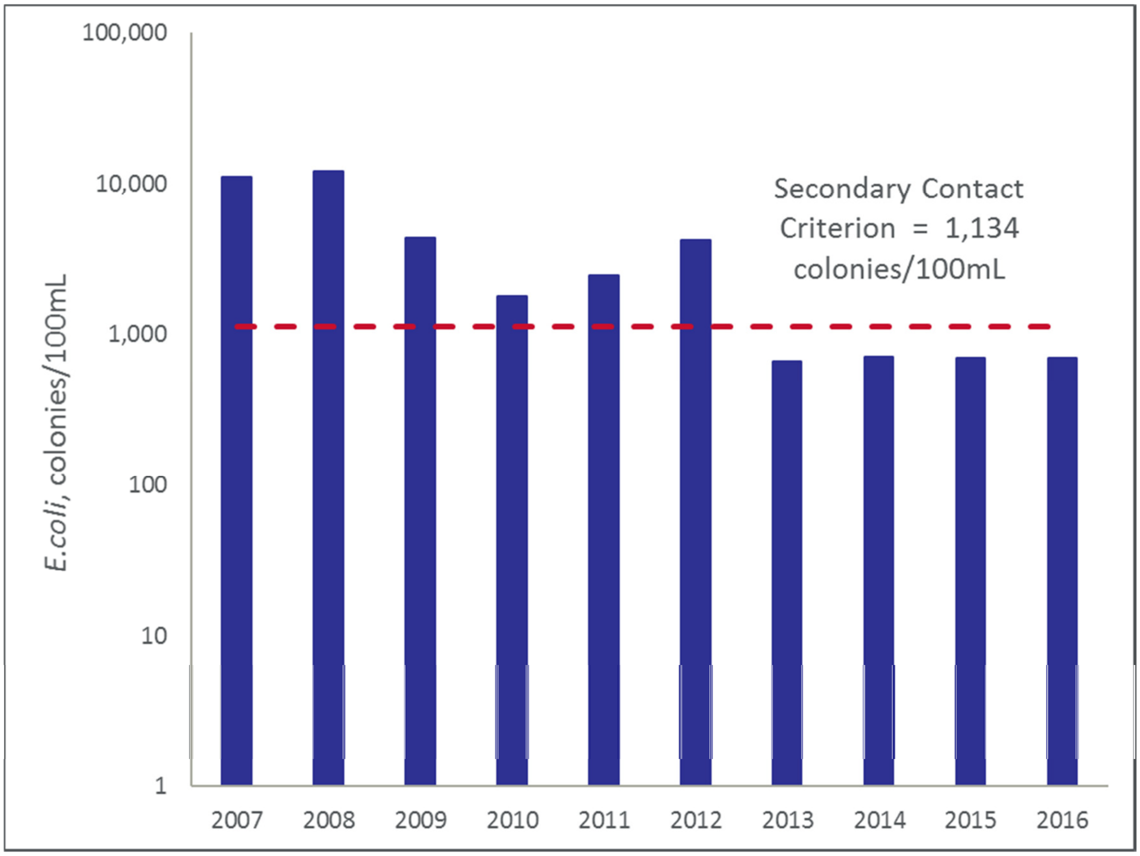

Figure 12. WLPS Effluent Annual Geometric Mean *E.coli* Concentrations.

Section 6. Summary

The CRWWTP performance assessment findings and summary points are as follows:

- Annual average influent flow, BOD_5 and TSS loadings have remained generally consistent since 2007.

- Annual average flow, BOD, TSS and ammonia loadings were consistently below the plant upgrade design criteria.

- Following the plant upgrade, the CRWWTP reduced the average annual ammonia influent concentrations by approximately 90 percent. Average effluent ammonia concentrations were consistently below the draft permit effluent ammonia limit. These findings confirm that the primary objective of the upgrade (ammonia removal) was achieved. Intermittent effluent ammonia concentration variability during the expanded plant startup period can be expected to be further reduced as process control measures are refined.

- Annual average influent ammonia loadings have shown a steady upward trend over the last several years. Much of this increase was expected due to the rerouting of internal sidestreams following the plant upgrade. The remaing portion of the increase was not yet identified. Ammonia loading trends should continue to be evaluated further to help identify ammonia loading sources.

- Average annual plant effluent BOD_5 concentrations decreased by approximately 30% following the plant upgrade.

- With the exceptions of waterfowl-related TSS excursions, the CRWWTP consistently complied with permit effluent limits.

- Average annual plant effluent *E. coli* concentrations were appreciably reduced following the plant upgrade. The annual average, post-upgrade *E. coli* concentrations were consistently below Missouri's secondary contact water quality criterion.

Technical Memorandum 3
Attachments

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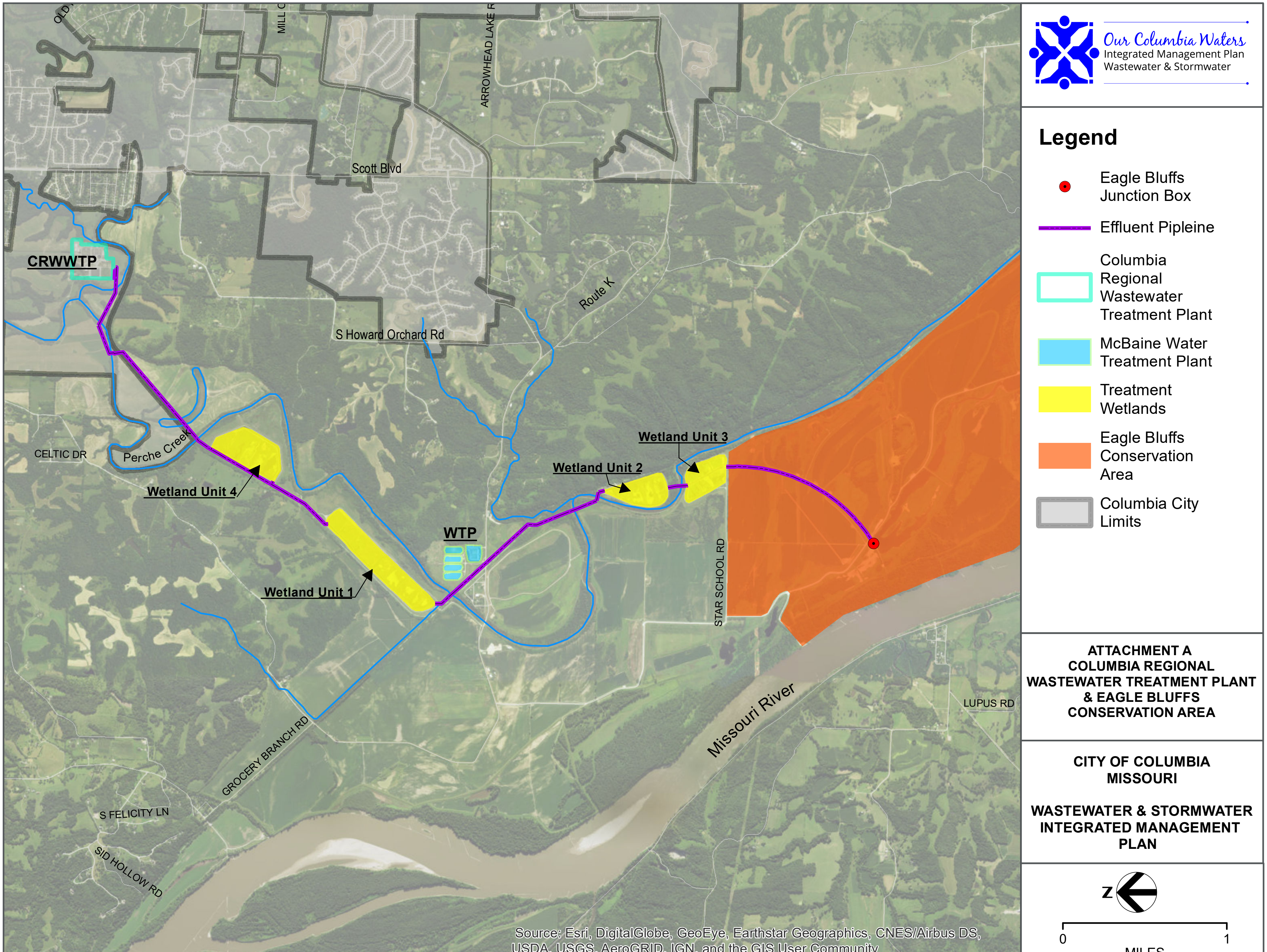


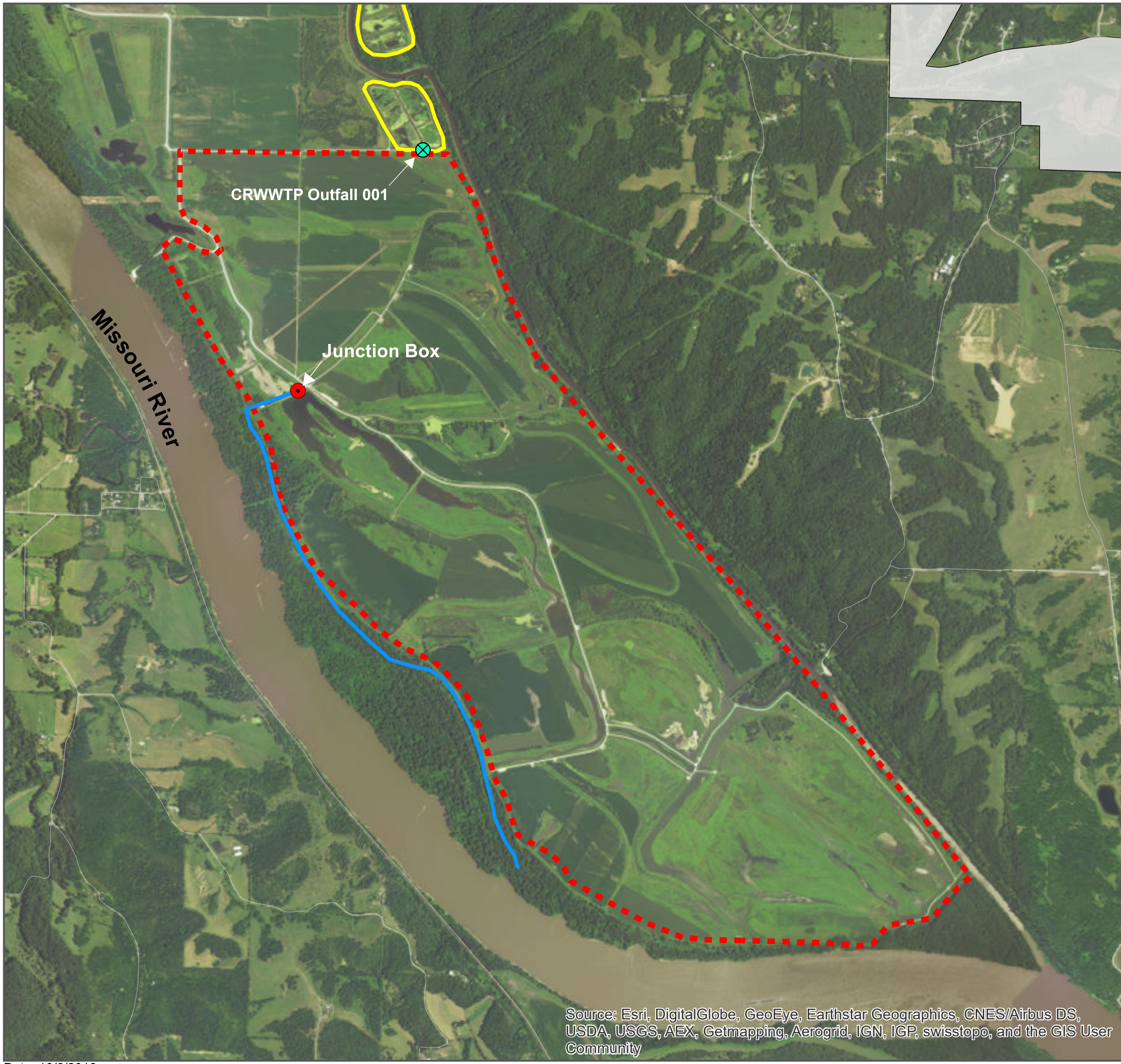
ATTACHMENT A
COLUMBIA REGIONAL WASTEWATER TREATMENT PLANT & EAGLE BLUFFS CONSERVATION AREA

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

Date: 11/28/2016

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater



ATTACHMENT B
EAGLE BLUFFS CONSERVATION AREA WETLANDS

CITY OF COLUMBIA MISSOURI

WASTEWATER & STORMWATER INTEGRATED MANAGEMENT PLAN

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Date: 10/6/2016