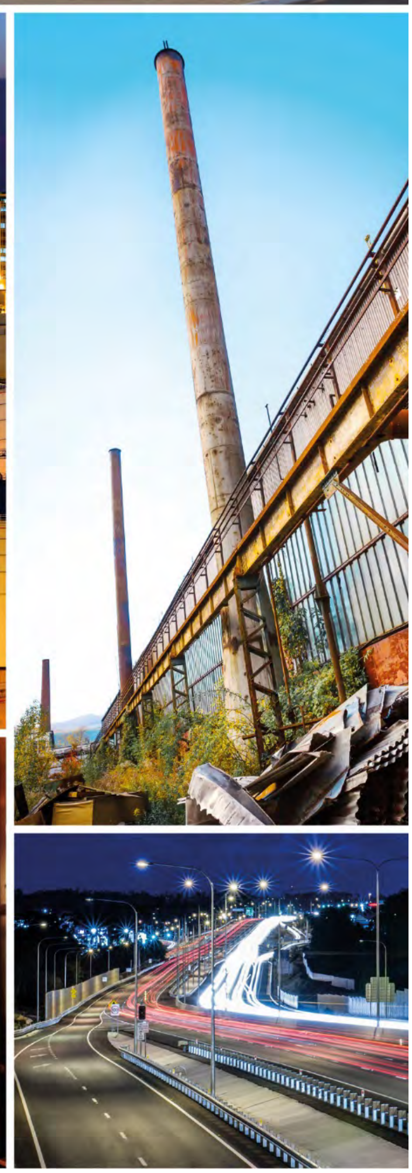
Cost-Benefit Analysis Report

Former Farmland Industries Nitrogen Plant
1608 N 1400 Road
Lawrence, Kansas 66046
KDHE Project Code: C4-023-00009



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GHD Project Number: 11152783

# Executive Summary

The Former Farmland Industries Nitrogen Plant Site (Site) is located in the City of Lawrence, Kansas (City) (Figure 1). Farmland Industries (Farmland) began manufacturing nitrogen fertilizers at the Site in 1954. Products manufactured and distributed by Farmland at this facility included anhydrous ammonia, granular urea, prilled ammonium nitrate, nitric acid, and urea-ammonium nitrate (UAN). Wastes generated as a result included sludge and wastewater that were released to soil, groundwater and surface water on and near the property. With approvals from the Kansas Department of Health and Environment (KDHE) and the United States Environmental Protection Agency (USEPA), previous extensive corrective actions were successfully completed by others on the south half of the Site. Therefore, GHD Services, Inc. (GHD) was contracted by the City in April 2018 to evaluate existing site data, identify and address data gaps, and prepare this Cost-Benefit Analysis (C-BA) report to address remaining legacy contamination present in the north half of the Site.

The City is actively redeveloping this Site as corrective actions are completed. The southern portion has been successfully re-purposed as a business park (VenturePark). The remaining northern portion, subject to this analysis, is currently being considered by the City for redevelopment as a Site for field operations for their Municipal Services Operations.

Farmland discontinued operations in 2002 due to an economic downturn in the global fertilizer market. In 2003, Farmland Industries, Inc., the parent company to Farmland Nitrogen, filed bankruptcy and placed funding for the future cleanup activities into the FI Kansas Remediation Trust (FI Trust). Between 2003 and 2010, the FI Trust, through SELS Administrative Services, LLC as Trustee, performed additional assessments and continued corrective actions as required and approved by the Kansas Department of Health and Environment (KDHE). In 2010, the City acquired the property and the remaining balance of the trust funds, with a long-term interest in commercially re-developing the site. Commercial re-development of the property and protecting public health and the environment from legacy nitrogen impacts in affected media remain the ultimate goals of the City.

The current applicable remedial action objectives (RAOs) for the Site, which were established in the Corrective Action Decision (CAD) (dated March 2010), serve as the basis for remedial alternative evaluations in this C-BA Report. The CAD RAOs are as follows:

- Groundwater
  - For Human Health – Prevent ingestion of on- or off-Site groundwater having nitrate contamination in excess of the federal drinking water standard for public water supplies of 10.0 mg/L
  - For Environmental Protection – Contain nitrate- and ammonia-contaminated groundwater on-site to prevent degradation of the downgradient Kansas River alluvial aquifer.

- Soil and Sediment
  - For Human Health – Prevent inhalation of fugitive vapors from surface and subsurface soil contaminated with ammonia in excess of Site-specific United States Environmental Protection Agency (USEPA) Preliminary Remediation Goals (PRG).
  - For Environmental Protection – Prevent migration of contaminants that would result in groundwater contamination in excess of 10.0 mg/L nitrate or surface water contamination in excess of background quality for nitrate and ammonia.
  - The Remedial Action Goals are established by the KDHE -Bureau of Environmental Remediation in BER-RS Policy # BER-RS-047 - Presumptive Remedy Policy Investigation and Cleanup of Nitrogen at Agriculture-Related Sites in Kansas, December 2014. In areas where no vegetation is present (i.e., contamination in a gravel roadway, parking area, etc.) the following Risk-based Standards for Kansas (RSK) standards apply:
    - Upper 8 inches of soil - 85 milligrams/kilogram (mg/kg) total nitrogen (N);
    - Below 8 inches in depth - 40 mg/kg total nitrogen (N).
  - In areas where vegetation is present (i.e., cultivated and cropped agricultural ground, pasture, lawn, etc.) the following RSK standards apply:
    - Upper 24 inches of soil - 200 mg/kg total nitrogen (N);
    - Below 24 inches in depth - 40 mg/kg total nitrogen (N).
  - USEPA calculated Site-specific PRGs for ammonia in soil based on the inhalation exposure pathway. The Site-specific PRGs are 385 mg/kg ammonia for the construction worker exposure scenario, 4,500 mg/kg for the industrial outside worker exposure scenario, and 1,060 mg/kg for the residential exposure scenario.
- Surface and Storm Water
  - For Human Health – Prevent ingestion of contaminated surface or storm water with nitrate in concentrations above the federal drinking water standard for public water supplies of 10.0 mg/L.
  - For Environmental Protection – Restore surface water and storm water quality leaving the Site to background quality for nitrate and ammonia.

Dating from the 1970’s, Farmland and the City have performed numerous voluntary and regulatory-mandated investigations and corrective actions to evaluate and mitigate impacts by the facility on the environment and public health. At the time of the bankruptcy in 2003, the remedial strategy for the Site included:

- Environmental Use Controls (EUCs), placed on the entire Site in 2013 to restrict human exposure to nitrogen impacted soil and groundwater;
- Establish and maintain groundwater hydraulic containment of off-site migration of nitrogen impacts in the Kansas River alluvial aquifer;

- Collect impacted storm water runoff and recovered groundwater for use as off-site fertilizer and irrigation of crops on farmland located north of the Kansas River;
- Perform targeted soil excavation with off-site disposal; and
- Perform targeted soil and pond sediments excavation with on-site interment beneath an impermeable vegetated cap.

The City continued this strategy after its acquisition of the Site in 2010 until 2017. In the fall of 2017, the City informed the KDHE that accumulations of recovered groundwater and affected storm water were exceeding onsite storage capacity and the needs for off-site fertilizer and irrigation by area farmers. The City obtained a temporary authorization (which expired in April 2018) from the KDHE to perform a closely monitored and controlled discharge of stored nitrogen-impacted groundwater and storm water directly to the Kansas River. The current remedial strategy involves recovery of groundwater from the alluvial aquifer to hydraulically control migration of contaminants from the Site. The recovered groundwater is discharged (without being treated) directly to a drainage way that connects the Site with the Kansas River.

In 2018, the City engaged the services of GHD to assist them in reviewing historical data, evaluating the current Site conditions, and proposing alternatives to the previously approved remedial strategy, which had proved to be no longer viable for the Site.

This C-BA Report presents the results of GHD's efforts since their engagement in April 2018. GHD and the City have performed the following significant activities during the preparation of this C-BA:

- The alluvial aquifer hydraulic containment system remains in operation;
- Operation of the interception trench drains was discontinued with approval from the KDHE until this comprehensive review of remedial alternatives could be completed and a new remedial strategy approved;
- Plans by the City to continue implementing KDHE corrective action according to the 2010 Remedial Design/Remedial Action Work Plan of impacted soil in areas of the Site designated for excavation and onsite landfilling was postponed, pending the completion of GHD's completion and the KD%HE's approval of alternative remedial strategies for the Site;
- GHD reviewed, assimilated, collated and evaluated the nearly 50 years of Site data stored by Farmland, KDHE, and the City;
- GHD evaluated current groundwater recovery systems operation and performance data;
- GHD actively participated in the administration, documentation review, and reporting of ongoing KDHE-required activities at the Site;
- GHD identified gaps in the evaluated data and Site history, which prevented completing the C-BA Report. Those gaps were investigated and the results reported in the Data Gap Study Report (GHD, February 2020). The data gaps included:
    - Hydraulic containment of nitrogen in the Kansas River alluvial aquifer required further testing and investigation;

- Nitrogen occurrence in groundwater, surficial and subsurface soil on and off-site was either missing or needed updating due to changing conditions;

- Collected groundwater samples from select Site monitoring wells for analysis of inorganic chemistry in order to evaluate potential complications of treating recovered groundwater.

GHD combined the new data with the voluminous historical database to form an updated conceptual site model (CSM) that describes the occurrence, fate, and transport mechanisms for the Site. GHD used the updated CSM as the basis for screening, evaluating, and ranking potential remedies for nitrogen in affected media.

The updated CSM is summarized as:

- Groundwater and soil are impacted by nitrogen in the forms of ammonia and nitrate at concentrations requiring corrective action in these areas of the Site (Figure 2) – Sandstone Hill, Central Ponds, Bag Warehouse, Western Ponds (Old West Pond, West Extension Pond, Krehbiel Pond), Former Plant A and Eastern Ponds (Rundown Pond, Overflow Pond, and East Lime Pond).

- Groundwater underneath Sandstone Hill is recharged by precipitation (rain water and snow melt) infiltrating permeable ground surfaces located upon Sandstone Hill itself. Groundwater within the Sandstone Hill hydrogeologic system flows vertically downward along fractures and planar interfaces between alternating layers of shale, sandstone, and siltstone. The lateral direction of groundwater flow radiates in all directions from the apex located along the ridge of the Sandstone Hill's north face. Nitrogen impacting surface and subsurface soil, and within the sandstone beneath Sandstone Hill are continuing to serve as a source to dissolved nitrogen impacts in groundwater.

- During seasons of enduring precipitation, shallow groundwater seeps to the ground surface along the steeper slopes of the west, south and southeast of Sandstone Hill. Storm water runoff occurs along these slopes due to very sparse vegetation.

- Separately, groundwater within the perched and alluvial aquifers along the northwest side of the Site is migrating away from the Site toward the east/northeast. The bottoms of the Eastern Ponds ((Rundown, Overflow and East Lime) in the northeast portion of the Site are lined with clay, which appears to be a competent barrier to leaching nitrogen to groundwater underlying the ponds.

While not specifically pertinent to future remedial actions at the Site, removal for off-site recycling of the two aboveground storage tanks and the substantial stockpile of re-bar reinforced concrete rubble located east of the Former Plant A will make nitrogen-impacted soil and groundwater in these areas more accessible and eventual site re-development of these areas more attractive. The City determined that the condition and ages of the ASTs render them physically and economically unsuitable for continued use in future remedial strategies (or in clean water distribution) for the Site. No useful purpose of the substantial stockpile of re-bar reinforced concrete rubble in future remedial strategies was identified.

After screening a list of potential applicable remedial technologies, GHD performed a detailed analysis of a list of assembled remedial alternatives based on estimated cost, compliance with current remedial action objectives, long-term effectiveness, and implementability.

The following summarizes GHD's recommended list of proven applicable remedial alternatives for **soil** (ranked in relative order based on pre-design preliminary lowest cost to highest cost, assuming a projected life cycle of not more than 30 years from the date of implementation):

- Minimizing or eliminating leaching of nitrogen from contaminated soils into groundwater and surface water by capping surface and subsurface contaminated soil in place with permeable vegetative or impermeable materials.
- Land application of groundwater and/or storm water runoff as fertilizer and irrigation water to onsite crops using nitrogen-impacted surface soil in terraces along sloped areas.
- Composting of excavated nitrogen impacted soil and using the finished composted material as fill or amendments to promote growth in sparsely vegetated areas of the Site.
- Constructed wetlands.
- Ex-situ aerobic removal of ammonia and anaerobic biological denitrification of nitrate-impacted soil.

The following summarizes GHD's recommended list of proven applicable remedial alternatives for **groundwater** (ranked in order from lowest cost to highest cost, assuming a projected life cycle of not more than 30 years from the date of implementation):

- Enhancing hydraulic containment of groundwater migrating off-site to the north in the alluvial aquifer by adding, relocating, and/or removing alluvial aquifer pumping wells.
- Discharging untreated groundwater directly to the surface water under the terms of a National Pollutant Discharge Elimination System (NPDES) permit.
- Land application of groundwater as fertilizer and irrigation water to onsite crops and vegetation.
- Constructed wetlands.
- Compositing (with or without nitrogen-impacted soil).
- Discharging untreated groundwater to the local sanitary sewer, after the City completes planned modifications to their treatment works to remove nitrogen.
- Using a manufactured industrial pre-treatment system to remove or reduce nitrogen followed by discharge to the surface water or to the City sanitary sewer system for additional nitrogen removal.

Approval of final remedial strategy(ies) will change the terms and conditions of the Department of Agriculture term groundwater recovery and storage permits, the National Pollutant Discharge Elimination System (NPDES) permit, and the long-term care agreement (LTCA) necessary to comply with current and future Environmental Use Controls (EUCs) for the Site.

Following the submittal of this C-BA the following sequence of events is anticipated:

1) Based on GHD's evaluation, the recommended corrective actions for the Site will include:

    a. In coordination with any redevelopment of the Site, capping areas of the Site using permeable and impermeable surfaces and dedicating areas of the Site to re-use as constructed wetlands. Surfaces where contaminated soil exists should be covered to the maximum practical extent and recovery of contaminated groundwater should be optimized to control off-site migration of impacted groundwater while minimizing the volume of recovered groundwater requiring treatment. Constructed wetlands appear to be the most cost-effective technology for treating recovered groundwater; however, bench and/or pilot testing this technology is necessary to determine the design, operation and maintenance sensitivities to mineral and contaminant concentrations. At such time as it may be both available and feasible, discharge of some (if not all) of the recovered groundwater to the City of Lawrence sanitary sewer system for biological nutrient removal appears an attractive technology worthy of further review in the future.

2) The KDHE will review and ultimately approve the C-BA and recommended remedial alternatives with contingencies.

3) The City will develop a Remedial Action Plan (RAP) that will include:

    a. Establish new remedial action goals.

    b. Plans for installing, testing, operating and maintaining recovery wells to hydraulically control areas of groundwater containing nitrogen at concentrations above remedial action goals.

    c. Plans for bench and/or pilot testing of constructed wetlands and composting.

4) The KDHE will approve the RAP.

5) The City and KDHE will renegotiate new or revised Consent Order, Corrective Action Decision (CAD), NPDES permit, and groundwater use permits.

6) The City will submit a new revised Corrective Action Plan (CAP) detailing proposed bench or pilot testing for industrial pre-treatment processes, composting soil and groundwater, and constructing and operating wetlands, new recovery well locations and construction, and interim plans for water management until such time as a more permanent treatment and discharge remedy is determined and approved.

7) The KDHE will approve the CAP

8) The City will implement the approved CAP.

# Table of Contents

# Figure Index

# Table Index



# Appendix Index

# Acronyms and Abbreviations

| | |
|---|---|
| CO | Consent Order |
| CAD | Corrective Action Decision |
| ERD | Enhanced Reductive Denitrification |
| EUC | Environmental Use Controls |
| EUCA | Environmental Use Controls Agreement |
| ft/day | feet per day |
| ft amsl | feet above mean sea level |
| KDHE | Kansas Department of Health and Environment |
| KDHE-BER | Kansas Department of Health and Environment – Bureau of Remediation |
| LTCA | Long Term Care Agreement |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per liter |
| NPDES | National Pollutant Discharge Elimination System |
| PRG | Preliminary Remediation Goal |
| RAO | Remedial Action Objectives |
| RWD | Rural Water District |
| TOC | Total Organic Carbon RO |
| USEPA | United States Environmental Protection Agency |

# 1. Introduction

The Former Farmland Industries Nitrogen Plant Site (Site) is located at 1608 N 1400 Road in the City of Lawrence, Kansas (City) (Figure 1). Farmland Industries (Farmland) began manufacturing nitrogen fertilizers at the Site in 1954. Products manufactured and distributed by Farmland at this facility included anhydrous ammonia, granular urea, prilled ammonium nitrate, nitric acid, and urea-ammonium nitrate (UAN). Wastes generated as a result included sludge and wastewater that were released to soil, groundwater and surface water on and near the property. With approvals from the Kansas Department of Health and Environment (KDHE) and the United States Environmental Protection Agency (USEPA), previous extensive corrective actions were successfully completed by others on the south half of the Site. Therefore, GHD Services, Inc. (GHD) was contracted by the City to prepare this Cost-Benefit Analysis (C-BA) report to address remaining legacy contamination present in the north half of the Site. This work is being performed under contract to the City and at the request of the Kansas Department of Health and Environment (KDHE) – Bureau of Environmental Remediation (BER).

The City engaged GHD in February 2018 to assist them in reviewing historical Site data, evaluating progress and effectiveness of current remedial actions, updating the conceptual site model (CSM), collecting supplemental information to satisfy identified data gaps, and developing alternatives to the current remedial strategy previously approved by KDHE in the Corrective Action Decision (CAD) (Appendix A), dated March 15, 2010. In order to prepare an updated CSM, GHD reviewed the extensive volume of historical data collected by others. During that review, GHD identified several data gaps that required additional or updated information. Following KDHE-BER's approval of the Data Gap Study (DGS) Work Plan (GHD, January 2019) GHD implemented the DGS in 2019. The DGS Report was submitted to the KDHE in December 2019. The final DGS Report addressing KDHE comments was submitted to the KDHE in February 2020.

Consent Order No. 10-E-94 BER between KDHE and the City became effective on September 29, 2010. Prior to the signing of the Consent Order, a Remedial Action Plan (RAP) was completed by Shaw Environmental for the FI Kansas Remediation Trust (SELS Administrative Services, LLC, Trustee). The City authored the Remedial Design/Remedial Action (RD/RA) work plan dated September 15, 2012. The RD/RA work plan summarized site conditions requiring remedial action, described the current status of interim remedial actions being implemented; included a description of the selected remedy and associated remedial action objectives (RAO's); described supplemental RD/RA tasks; provided a schedule for the completion of those tasks; and discussed issues to be addressed during remedial design.

Since the implementation of the RD/RA work plan, the City continued to monitor groundwater, implement hydraulic containment of nitrogen impacts in on-site perched groundwater and off-site alluvial aquifer groundwater, installed the Central Ponds interception trench system, installed the regional retention basin, and excavated soil containing ammonia and nitrate from the Central Ponds area. The excavated soils were relocated to the West Lime Pond.

This C-BA was commissioned to develop a new comprehensive remedial strategy to replace the current non-viable long-term remedial strategy of using recovered groundwater as fertilizer and irrigation of farm ground located north of the Kansas River. Additionally, alternative soil remediation strategies were evaluated to supplement or replace on-site landfilling of excavated soil as described in the CAD and RD/RA work plan.

### 1.1 C-BA Scope and Objectives

The purpose of this C-BA Report is to:

- Review the remedial history of the Site.
- Summarize the DGS findings and update the CSM.
- Summarize Site-specific RAOs for soil and groundwater.
- Describe potential remedial alternatives appropriate for the Site.
- Develop generalized cost estimates based on preliminary engineering designs.

## 2. Site Description

The Site is located at 1608 North 1400 Road in Lawrence, Kansas in Douglas County within Sections 4 and 5 of Township 13 South, Range 20 East. The original Site encompassed approximately 467 acres, not including approximately 30 acres of farm ground located between the BNSF Railroad right-of-way and 15th Street. More than 200 acres of land in the southern part of the Site have been redeveloped as an industrial park known as the Lawrence VenturePark business park. The location of relevant areas of the Site subject to this C-BA are illustrated in Figure 1. The Site lies between Kansas State Highway K-10 on the south and 15th Street to the north. Land use in the Site's vicinity includes commercial/industrial and residential use to the west, and commercial/industrial use to the south and east. Agricultural land occupies areas beyond East 1500 Road north of the Site, and the Kansas River flows east-southeasterly approximately one-half mile north of the Site. The Site is zoned for commercial and industrial use.

Topography of the west side of the Site is dominated by Sandstone Hill with an elevation of approximately 900 feet above mean sea level (amsl). The topography of the east side of the Site is flat with an elevation of approximately 820 feet amsl.

Geology of the highlands on-site is comprised of unconsolidated clay overburden overlying alternating layers of shale, siltstone, and sandstone. Geology of the lowland is described as terrace deposits overlying sandstone and shale on the south trending to a sandy alluvial aquifer to the north which increases in depth and thickness toward the main river channel.

The Site is generally divided into the following specific topographic areas of interest: Sandstone Hill, Central Ponds, Plant A, Western Ponds, Eastern Ponds, Bag Warehouse, and Site-wide Groundwater.

## 3. Site History

Manufacturing of nitrogen fertilizers began at the Site in 1954 and ended in 2001. Products manufactured and distributed by Farmland at this facility included anhydrous ammonia, granular urea, prilled ammonium nitrate, nitric acid, and urea-ammonium nitrate (UAN). Wastes generated as a result included sludge and wastewater that were released to soil, groundwater and surface water on and near the property.

Until 1987, UAN product was stored in ponds located on top of Sandstone Hill. The ponds were replaced in 1988 with above ground storage tank (AST) #6 which is situated within a secondary containment basin countersunk into the top of the bluff to a depth of approximately 20 feet. The area of the secondary containment basin of this AST is approximately 2.5 acres.

The Central Ponds were designed to control surface water flow from the south side of Sandstone Hill during heavy rain events. Over time, the ponds and their sediments became contaminated with nitrogen.

Plant A was an area where many of the solid fertilizer manufacturing processing operations were centrally located. The majority of Plant A is currently paved with asphalt or concrete surfaces. The subsurface of Plant A is crisscrossed by a network of out of service abandoned process, utility, and waste discharge piping. The plant buildings and the north bulk fertilizer warehouse were demolished and removed from the Site after the City acquired the property in 2010. The former South Bulk Nitrate Warehouse is still intact and located within the south end of the former Plant A area of interest. The South Bulk Nitrate Warehouse is used by the City primarily for road salt storage.

The Bag Warehouse covers an approximate area of two acres along the foot of the northern slope of Sandstone Hill. The area was historically used for storage and shipping of bagged fertilizer via truck and railcar.

Wastewater was managed on-site in a series of process water (Western Ponds), and waste water settling/evaporation ponds (Eastern Ponds). The sides and bottoms of the wastewater ponds were constructed from on-site low-permeability native clay. During normal operating conditions, much of the wastewater could be re-used in the manufacturing processes. After the plant ceased operating in 2002, recovered surface water and groundwater from hydraulic containment of nitrogen-impacted surface and groundwater was stored in the ponds and in on-site AST #5 (2.5 million gallons capacity) and AST #6 (5.5 million gallons capacity). This recovered groundwater was pumped north of the river and land applied as irrigation and fertilizer on crops.

# 4. Current Remediation System Status

The remediation systems for the former Farmland Industries Nitrogen Plant involve recovery of nitrogen-impacted groundwater by interception trenches and groundwater extraction wells. Recovered groundwater is pumped directly to the surface water in compliance with the existing NPDES permit for the remediation systems. In the past, recovered groundwater was pumped alternately to the Southeast Sump, AST #5, and AST #6. From the Southeast Sump, recovered groundwater could be diverted to either of the ASTs or to the Overflow and Rundown Ponds.

According to the design and the CAD, on a seasonal or as-needed basis, stored nitrogen-impacted groundwater was historically pumped from the ASTs to farm fields located north of the Kansas River (to be used as a supplemental fertilizer) via a pipeline buried beneath the riverbed. The demand for this end-use of recovered groundwater has been declining in recent years, which has caused the City to consider alternative remedial strategies.

In addition to comprehensive Site-wide environmental use controls (EUCs) in place on soil and groundwater, the current remediation systems at the Site consist of:

1. Recovery of groundwater from the deeper Kansas River alluvial aquifer by four vertical extraction wells: PW-9, PSW-3B3, PSW-6B3, and PSW-7B2.
2. Recovery of groundwater from sumps connected to six separate perched groundwater interception trenches: Central Ponds, North, South, Northwest, Northeast, and Southeast.
3. Storage of recovered groundwater in two ASTs: AST #5 (2.5 million gallons capacity) and AST #6 (5.5 million gallons capacity).
4. Storage of recovered groundwater in five former wastewater ponds which remain part of the groundwater remediation system: Overflow, Rundown, Old West, Krehbiel, and West Extension. A sixth pond was constructed in 2016 by combining the former West and East Effluent Ponds to create the Regional Detention Basin (Figure 2). The Regional Detention Basin is designed to store storm water runoff from a developed area south of the Site known as the Lawrence VenturePark business park. Storm water quality discharged from the Regional Detention Basin is subject to the National Pollutant Discharge Elimination System (NPDES) (permit number I-KS31-PO04) dated 2017 (expiring in 2021) monitoring requirements for the Site. Documentation of compliance is maintained by analyzing samples collected periodically from Outfall 001B1 in accordance with the permit.
5. The Kansas Department of Agriculture, Division of Water Resources issued two permits to the City for the remediation of the Site. Groundwater Term Permit 20119061 issued in 2011 (expiring in 2031) allows the withdrawal of “contaminated” groundwater from four extraction wells and six sumps for the purpose of land application as fertilizer. Groundwater Term Permit 20059013 was issued in 2010 (expiring in 2020) to operate the ponds as diversionary surface impoundments of “contaminated” water for the purpose of land application as fertilizer. Discharge of untreated groundwater to fertilize and irrigate crops or discharged to the Site’s NPDES-permitted outfall 001A1. Discharges from 001A1 eventually run to the Kansas River and are estimated to be 0.4 million gallons per day (mgd). The NPDES permit estimates discharges via permitted outfall 001B1 from the Regional Detention Basin to be 0.3 mgd.
6. Under terms of the CAD and the NPDES permit, the remediation system is designed to store recovered groundwater until the water can be used as fertilizer on farm fields located north of the Kansas River. Currently, the City operates only the alluvial wells. As approved by the KDHE, groundwater recovery from the trenches remains suspended pending the completion of review of the overall remediation strategy for the Site.

In August 2017, KDHE approved the City’s request to suspend operation of the interception trenches because the volume of recovered groundwater exceeded storage capacity and the quantity required for land application. The City requested assistance from KDHE to explore alternatives for discharge, treatment and/or disposal of the stored groundwater. In September 2017, KDHE authorized release of stored groundwater to surface water until April 2018, accompanied by periodic monitoring and reporting of total volume, flow rate, pH and nitrogen concentrations.

While the interception trenches remain idle, the alluvial groundwater extraction system continues operation to comply with the CAD requirement of hydraulic containment of nitrogen impacts in the alluvial groundwater zone. Recovered groundwater is currently being discharged to the Site's NPDES-permitted outfall in compliance with the Site's NPDES permit conditions. The ponds and the ASTs are currently not in active use. Monthly and quarterly monitoring and reporting are being performed by the City.

# 5. Summary of DGS

## 5.1 DGS Scope

During the review, GHD identified three significant gaps in chemical or physical data, which were necessary to fill in order to complete an update to the CSM and prepare an updated cost-benefit analysis. The DGS investigation was conducted in accordance with the procedures and protocols presented in the 2018 DGS Work Plan, dated November 16, 2018. Under the DGS Work Plan, GHD:

i. Performed aquifer tests on the four existing alluvial extraction wells (PW-9, PSW-3B3, PSW-6B4, and PSW-7B2).

ii. Performed a more comprehensive aquifer test on the PW-9 extraction system separate from the combine extraction system to define the hydraulic characteristics of the alluvial aquifer and calculate an appropriate pumping rate to establish hydraulic containment.

iii. Collected soil and groundwater samples from the areas surrounding the Bag Warehouse, the West Extension Pond, PSW-5B2, the West Lime Pond, the Rundown Pond, and the East Lime Pond for nitrogen mass characterization and downgradient migration.

## 5.2 DGS Findings and Conclusions

Copies of figures summarizing/illustrating the data collected during the DGS and included in the DGS Report are included as Appendix B. Further discussion of the methods and data interpretations are found in the DGS Report. The following findings and conclusions were included in the DGS Report:

1. The Bag Warehouse area does not appear to represent a significant source area. However, impacted groundwater from the up-gradient Sandstone Hill appears to be migrating underneath the Bag Warehouse area into the alluvial aquifer and off-site. PW-9 captures a portion of the nitrogen affected groundwater. The updated aquifer analysis indicates higher extraction flow rates than the current pumping rate of 13 gallons per minute (gpm) are achievable and may be needed to improve capture of nitrogen affected groundwater at the location.

2. The Western Ponds area contains significant nitrogen mass that occur mostly within the low permeability silty clay near surface terrace deposits. These low permeability deposits appear to inhibit off-site migration as evidenced by the low nitrogen detections found off-site in soil and groundwater near PSW-5B2.

3. The Eastern Ponds area also shows high relative nitrogen concentrations within the low permeable deposits. However, the underlying sandy alluvial aquifer deposits do not show

elevated nitrogen levels and indicate the terrace deposits are an effective aquitard that limits downward migration of nitrogen compounds, especially in the absence of hydraulic loading when the ponds are empty.

4. The current groundwater extraction system is not effectively capturing migrating impacted groundwater in the areas of PW-9 and PSW-5B2. Current groundwater analytical data from the recovery wells and monitoring wells in the area of the Eastern Ponds indicates low or no concentrations of nitrate and ammonia. The groundwater system downgradient of the East Ponds area provide no apparent remedial benefit based on the DGS data.

# 6. Conceptual Site Model

Based on the DGS findings and a comprehensive review of Site data, the following CSM was prepared for each area of interest. Maximum nitrate concentrations currently or recently observed in soil are summarized in Table 1. Maximum nitrate concentrations currently or recently observed in groundwater are summarized in Table 2.

## 6.1 Sandstone Hill

The data indicates that the nitrate and ammonia from operating UAN ponds formerly located on top of the Sandstone Hill leached downward into the fractured shale and sandstone. The nitrogen impacts were further mobilized by surface infiltration of precipitation and groundwater flowing underneath the hill from the southwest.

The surface soils on Sandstone Hill are comprised primarily of clay and weathered shale and sandstone. Nitrogen impacted surface runoff from precipitation events flows via sheet flow to the west, south and east. Seeps of groundwater have been observed in rock outcrops and exterior sides on the west, south, east and north sides of the bluff. Groundwater that successfully percolates to the interior base of the hill via fractures within the interbedded layers of sandstone, shale, and siltstone eventually transport dissolved nitrogen and minerals to the perched groundwater within the terrace deposits and eventually into the underlying regional Kansas River alluvial aquifer.

## 6.2 Central Ponds

In 2006, 1,300 cubic yards of nitrogen impacted soil were removed and relocated to the East Lime Pond. The area was restored using approximately 2,700 cubic yards of imported fill soil. Due to ongoing seepage of nitrogen-impacted groundwater from the south side of Sandstone Hill, which re-impacted the Central Ponds area, additional remedial work was approved by KDHE. In 2014, a shallow groundwater interception French drain system was installed on the north and south sides of the access road that traces along the north edge of the Central Ponds area. The trench is connected to a subgrade sump. Under previous remedial operations, groundwater gathered by the Central Ponds sump was pumped to the ASTs for reuse in irrigation and fertilizer of crops north of the river.

## 6.3 Plant A

Historical operation and waste management practices impacted the soil and groundwater throughout this area. Due to the network of former utilities, some of which were cleaned and abandoned in place, access to the soil and groundwater in this area for the purpose of implementing active remediation technologies is extremely limited.

Previous investigations have documented nitrogen contamination in soil and groundwater near and beneath the South Bulk Nitrate Warehouse.

## 6.4 Western Ponds

The Western Ponds – Krehbiel, Old West and West Extension – were once a key part of the manufacturing process. Historical practices resulted in releases of nitrogen to soil and groundwater in and beneath the ponds. The DGS confirmed that substantial nitrogen mass remains in this area both in the unsaturated soil and groundwater. This area may also be affected by groundwater seepage from the Sandstone Hill into the unconsolidated sols that abut against the bedrock. These nitrogen impacts appear to be affecting the perched and alluvial groundwater quality downgradient to the northwest, north and northeast.

## 6.5 Eastern Ponds

The Eastern Ponds were used to store and manage the Site's waste and cooling waters. The DGS indicated that the pond bottoms are constructed of a native very low permeability clay and within the Newman Terrace Deposits. These low permeability materials have effectively inhibited downward migration of nitrogen compounds into the alluvial aquifer.

## 6.6 Bag Warehouse

The data indicates that the nitrate and ammonia impacts to surface and subsurface soil in this area is a result of former operations and releases to the environment which occurred during the transfer of final product to truck and rail. Since the area is effectively covered with an impermeable cap (the warehouse and supplemental paving), impacts to the groundwater appear to be the result of groundwater flowing beneath the warehouse from Sandstone Hill and carrying dissolved nitrogen north toward PW-9.

## 6.7 Site-wide Groundwater

The primary concern and regulatory driver that must be addressed in order to protect public health and the environment is the Kansas River Alluvial aquifer which is located downgradient from, beneath, and adjacent to, the northeastern side of the Site. Occurring at a depth of approximately 30 feet below ground surface and with a thickness of approximately 30 feet, this aquifer is a regional drinking water resource, with several local domestic wells located downgradient from the Site, and between the Site and the Kansas River. Regionally, the alluvial groundwater gradient is gentle, with a direction of groundwater flow consistent with that of the river, which meanders east/southeast in the vicinity of the Site.

The Site groundwater has been impacted by past Site operations. In particular, Sandstone Hill represents a significant source to groundwater impacts. Given its topographic location, Sandstone Hill is a groundwater recharge source that discharges radially into the adjoining unconsolidated sediments and vertically into the fractured sandstone, siltstone and mudstone comprising its core. If contaminated groundwater discharges into the sandy alluvial sediments it can readily migrate off-site, unless captured by the existing or an augmented groundwater extraction system. In some instances, the groundwater discharges have been documented to the ground surface as seeps, which then migrate as surface water down-slope to the west, and the south to the former Central Ponds area and to the north and east toward the Western Ponds areas.

The Newman Terrace Deposits are low permeability sediments that appear to effectively inhibit nitrogen-impacted groundwater migration, particularly in the Eastern Ponds area where minimal impact to the alluvial aquifer was observed during the DGS . In the Western Ponds area, the unsaturated terrace deposits are relatively thick (>20 feet, approximately) and are capable of retaining significant nitrogen mass. While downgradient nitrogen impacts are observed off-site in groundwater at monitoring well PSW-5B2, the relative concentrations are orders of magnitude lower compared to concentrations measured on-site.

The Kansas Alluvial Deposits are permeable sand deposits that are capable of transmitting substantial quantities of water. The hydraulic testing shows the alluvial aquifer to be transmissive with a groundwater flow velocity between 0.5 to 1.0 ft/day (180 to 365 ft/yr). The high alluvial aquifer transmissivity is inversely proportional to hydraulic containment. Hence, PW-9 pumping at its current flow rate of approximately 13 gallons per minute (gpm) (exerting approximately 0.5 feet of drawdown within the well) only effectively intercepts the portion of the nitrogen plume migrating underneath the Bag Warehouse area and a potentially significant portion of the plume may be allowed to migrate off-site. The recovery rate of PW-9 was limited primarily due to the size of the pump, which is the highest capacity pump available which will both physically fit inside the well and match the 110 volts AC power supply nearby. In October 2019, the City installed an upgraded 240 VAC power supply and installed a higher capacity pump, which is now operating near 25 gpm continuously.

With respect to the other three groundwater extraction wells (PSW-3B3, PSW-6B4, and PSW-7B2), based on their groundwater effluent data indicating low to non-detect nitrogen concentrations, these wells are providing no apparently useful remedial benefit. Each of these wells were installed with the designed purpose to recover approximately 25 gpm. Instead, each well is operated at the maximum pumping rate that a combination of the pump, well and aquifer will permit. That is, the throttling valve is fully open, however, mineral scaling in the pump, piping and well build up over time requiring frequent routine maintenance to clean. Meanwhile, each well is operated continuously at the highest flowrate possible at or near its design of 25 gpm. It is important to note that the groundwater concentrations of nitrate within the influence of these three recovery wells is below that requiring capture and containment of 10 mg/L. Based on the hydraulic testing, each of the alluvial recovery wells should be capable of supporting sustained yields in excess of 50 gpm. Due to the mineral scaling potential within the alluvial aquifer, redundancy of recovery wells will be necessary so that hydraulic control will not be disrupted during periods of shutdown while routine maintenance is performed. For the purposes of remedial alternative comparisons and cost estimating, an average flowrate of 25 gpm from each of four alluvial recovery wells was assumed. Additionally, an assumed 100 gpm of storm water impacted with COCs will be contained onsite with the recovered groundwater. Adding an additional design factor of 50% brings the total water flow rate for the basis for design to 300 gpm for the purposes of sizing and costing conveyance, storage, treatment and disposal systems.

While maximum concentrations within individual recovery and monitoring wells fluctuate, the design concentrations of 300 mg/L ammonia as N and 500 mg/L nitrate as N were assumed for comparison purposes. Groundwater or storm water with much lower concentrations of COCs than those assumed for comparison purposes will be used to dilute groundwater with higher concentrations.

# 7. Remedial Action Objectives

The current applicable RAOs for the Site, which were established in the CAD (dated March 2010), serve as the basis for remedial alternative evaluations in this C-BA Report.

This C-BA assumes two very important remedial criteria will not change:

1. Some form of remedial action will be required so the “No Action” Alternative was used as a base-line against which all of the alternatives were evaluated; and
2. Any re-negotiation of the CAD will not change the current RAOs.

## 7.1 Soil

The CAD RAOs for soil and sediment are as follows:

- For Human Health – Prevent inhalation of fugitive vapors from surface and subsurface soil contaminated with ammonia in excess of Site-specific United States Environmental Protection Agency (USEPA) Preliminary Remediation Goals (PRG).
- For Environmental Protection – Prevent migration of contaminants that would result in groundwater contamination in excess of 10.0 mg/L nitrate or surface water contamination in excess of background quality for nitrate and ammonia.

The Remedial Action Goals are established by the KDHE-BER in BER-RS Policy # BER-RS-047 - Presumptive Remedy Policy Investigation and Cleanup of Nitrogen at Agriculture-Related Sites in Kansas, December 2014. In areas where no vegetation is present (i.e., contamination in a gravel roadway, parking area, etc.) the following Risk-based Standards for Kansas (RSK) standards apply:

- Upper 8 inches of soil - 85 milligrams/kilogram (mg/kg) total nitrogen.
- Below 8 inches in depth - 40 mg/kg total nitrogen.

In areas where vegetation is present (i.e., cultivated and cropped agricultural ground, pasture, lawn, etc.) the following RSK standards apply:

- Upper 24 inches of soil - 200 mg/kg total nitrogen.
- Below 24 inches in depth - 40 mg/kg total nitrogen.

USEPA calculated Site-specific PRGs for ammonia in soil based on the inhalation exposure pathway. The Site-specific PRGs are 385 mg/kg ammonia for the construction worker exposure scenario, 4,500 mg/kg for the industrial outside worker exposure scenario, and 1,060 mg/kg for the residential exposure scenario.

## 7.2 Groundwater

The CAD states the following RAOs for groundwater:

- For Human Health – Prevent ingestion of on- or off-site groundwater having nitrate contamination in excess of the federal drinking water standard for public water supplies of 10.0 mg/L
- For Environmental Protection – Contain nitrate- and ammonia-contaminated groundwater on-site to prevent degradation of the downgradient Kansas River alluvial aquifer.

## 7.3 Surface and Storm Water

The CAD states the following RAOs for surface and storm water:

- For Human Health – Prevent ingestion of contaminated surface or storm water with nitrate in concentrations above the federal drinking water standard for public water supplies of 10.0 mg/L.
- For Environmental Protection – Restore surface water and storm water quality leaving the Site to background quality for nitrate and ammonia.

# 8. Potential Remedial Technologies

A summary of potential remedial technologies screened for this Site are summarized on Table 3. Each potentially applicable technology was screened against the others for ease of implementation, relative cost, and effectiveness. Due to the high clay content of unconsolidated near surface soils and the presence of consolidated shale and sandstone near the ground surface, excavation of nitrogen-impacted soil is not likely to prove economical. Likewise, removing groundwater from within consolidated sandstone of low permeability would not be cost effective compared to the perceived benefit. Therefore, in situ remedial technologies, such as injection or permeable reactive barriers, were screened out of further consideration due to practical implementation limitations. Ex situ remedial technologies that were screened out of further consideration due to the relative cost compared to other less costly technologies or because they have the potential to generate a waste stream that would be equally or more challenging to treat/dispose than the perceived benefit when compared to alternative in situ technologies include: excavation with off-site disposal, soil stabilization or solidification, ammonia stripping, and industrial scale evaporation.

With the operation of the Regional Detention Basin to control the flow of non-impacted storm water from the Site and the planned discontinued use of the Eastern Ponds to store water, continued operation of the interception trenches near these ponds will no longer be needed. Likewise, covering the Sandstone Hill and Central Ponds areas will mitigate infiltration of precipitation, thus rendering the continued operation of the Central Ponds Trenches unnecessary.

The following sections describe each retained technology evaluated in this C-BA.

## 8.1 Soil

### 8.1.1 Impermeable Capping

Impermeable capping of soil either in place or after it has been excavated and relocated is a straightforward approach to immobilizing the contaminants within the soil. Capping is accomplished by grading the area of impacted soil to promote drainage, and preparing the surface of the soil to be capped by compaction. After compaction, an impermeable material or layers of impermeable materials are applied. Impermeable materials are typically polymer membranes, clay, pozzolanic cements mixed with native soil then hydrated, concrete or asphalt. The top layer is often selected based on cost and the intended future use of the covered area.

Maintenance of this technology includes routine annual inspections followed by repairs or replacement of areas where the structural integrity of the cap has been compromised. Additional maintenance may include management of increased storm water runoff controls or erosion.

Depending on planned re-use of redevelopment of the Site, combining impermeable capping with vegetated covers (described in the next section) may be necessary or more economical, while achieving the same goal: limit or eliminate infiltration of precipitation which could leach contaminants into the groundwater.

### 8.1.2 Vegetated Cover

Vegetated covers are constructed by covering an existing area of impacted (or an excavated and relocated stockpiled) soil with an overlying layer of topsoil and supplemented with such amendments as necessary to support vegetation. Once established, the vegetation will prevent the erosion of the topsoil layer over time. Precipitation either evaporates or is uptaken by the vegetation. While some water may infiltrate to the contaminated soil layer, it is typically in insufficient quantities to result in significant mobilization of contaminant mass. In the case of nitrate and ammonia, both are necessary nutrients for sustainable plant growth, thus plant roots that reach the nitrogen impacted soil will uptake what they need.

Maintenance of vegetated covers includes routine annual inspections followed by any needed repairs or replacement to preserve the intended purpose of the cover. Areas where water may pond or where runoff has eroded the cover should be filled, re-seeded and mulched. During the growing season, the cover should be mowed and application of herbicides to control noxious and invasive species should follow all appropriate manufacturer directions to avoid over-application.

Depending on planned re-use of redevelopment of the Site, combining vegetated covers with impermeable capping (described in the previous section) may be necessary or more economical, while achieving the same goal: limit or eliminate infiltration of precipitation which could leach contaminants into the groundwater.

### 8.1.3 Composting

Composting requires intimate mixing of contaminated media with water, nutrients, and carbon. The soil at the Site contains high enough concentrations of nitrogen that adding more may not be necessary. The clay/silt content of the soil however appears to be significantly free from organic matter and, unless excavated below the water table (which is to be avoided), the surficial unsaturated soil will be too dry to promote or sustain composting without the addition of water. Additional water is available from the groundwater extraction systems, i.e., interception trenches and alluvial groundwater recovery wells. Supplemental organic matter will need to be imported either as solid (tree and yard debris) or liquid (e.g., dilute solutions of emulsified vegetable oil (EVO)). Results will vary with the heterogeneity of the soil, seasonal precipitation, the nitrogen content in the soil and added water, and the type of organic matter applied. Bench and or pilot testing is typically required to refine initial ratios for each raw material input.

Maintenance of the composting facilities include monitoring and adjusting moisture of the compost pile or heap. Periodically, samples of the composted material should be analyzed to determine the composting rate, and to optimize carbon amendment and moisture content. Equipment used to shred or apply carbon to the composting process should be maintained according to manufacturer recommendations.

### 8.1.4 Farming

Farming of the surface soil will involve a similar amendment program to composting. Agricultural testing of the soil should be performed to determine the type and quantities of amendments to support and sustain growth of the desired crop. In some areas, the ammonia concentrations may be sufficiently toxic so as to limit the potential farming of an area without the addition and blending of bulking agents like imported fill soil or onsite generated compost or shredded organic matter (i.e., recycled yard and tree debris). Farming (aka phytoremediation) has three benefits: 1) deep soil mixing (i.e., tilling at depths greater than 2 feet) can effectively aerate soil promoting infiltration of water and oxygen to stimulate and maintain plant growth, 2) if successful, crops may be harvested for beneficial use, remaining organic matter (e.g., stubble and chaff) can be tilled into the soil and additional crops planted, and 3) groundwater containing nitrogen generated by the extraction systems on Site may be used to supplement precipitation during times of drought.

Maintenance of the farming areas will include controlling erosion, reducing standing water to avoid drowning vegetation, applying appropriate amounts of herbicide as needed and harvesting any crops or hay at the appropriate intervals.

### 8.1.5 Constructed Wetlands

Some of the excavated or in-place soil may be re-used to assist in construction of wetlands. Soil that contains nitrogen and ammonia could be used as fill under and surrounding constructed wetlands. Once in operation, the nitrogen sorbed onto the soil will be dissolved by the water flowing through the wetlands making it available to sustain plant growth within the wetlands or to be biologically degraded. As part of the construction process, nitrogen within these soils will be subject to the same biological processes that beneficially remove nitrogen from groundwater.

Maintenance of constructed wetlands will involve monitoring influent COC concentrations and water flowrate. At least quarterly, it is recommended that the constructed wetlands be inspected and correcting any areas where short circuiting of desired flow-paths may have occurred. It is recommended to perform routine quarterly inspection of all water recovery and conveyance systems and manually clean any biofouling or mineral scaling before these could result in unplanned system shutdowns.

## 8.2 Groundwater

### 8.2.1 Hydraulic Containment

Monitoring data reported routinely to the KDHE has documented that nitrate concentrations in off-site downgradient monitoring wells remains below 10 mg/L (with the exception of PSW-20B) indicating that the current remedial strategy of hydraulic containment appears to have been effective in preventing migration of nitrogen impacted groundwater beyond the property boundaries of the Site. Supplemental to this, then, would be to identify ways to improve and expand on this success. According to current operating and monitoring data, continued recovery of alluvial aquifer groundwater in the vicinity of PSW-6B, PSW-7B and PSW-3B does not appear to be necessary. The DGS data supports shifting that focus toward the west between PSW-5B2 and PSW-20B. According to the aquifer testing and subsequent preliminary hydraulic influence modeling conducted during the DGS, higher individual recovery well flow rates of 50 to 60 gpm would exert a wider cone of influence than the current 15 to 25 gpm per recovery well flow rate under the current strategy.

It is important to note that while higher individual (on total) flow rates are achievable, resulting in greater influence exerted on the impacted groundwater, the final concentration of COCs in the recovered groundwater is unknown at this time. Operating data to date shows an overall decline of dissolved concentrations of nitrate and ammonia. Increasing and enhancing existing cover and capping on Site should further this trend, even without hydraulic containment. Also, should higher concentrations than current trends project be noted during vigilant monitoring, additional groundwater from areas of lower concentrations of COC could be used to control (i.e., dilute) the overall concentrations requiring treatment to within the range for which the composting, engineered wetlands or any of the other treatment technologies were designed to treat.

Maintenance of this technology will include performance monitoring of individual recovery wells to analyze trends in pumping rate versus drawdown within the pumping and nearby monitoring wells. This is an early indicator of fouling and provides time to schedule maintenance, thus minimizing interruption to the operating schedule. Preventative maintenance of recovery wells and piping is typically performed at least annually. Inspections of equipment (valves, flowmeters, piping, etc.) is useful in identifying potential failures before they occur and allows time to schedule repairs or replacement of key components before they fail.

### 8.2.2 Composting

Depending on the volume of soil being composted at any given time, it may be necessary or desirable to divert some groundwater generated from hydraulic containment in order to promote or accelerate ex situ composting of nitrogen impacted soil in order to reduce the amount of groundwater requiring treatment by another remedial technology. The concentrations of nitrogen, the amount of organic matter, and the amount of water applied would be monitored and inputs adjusted to optimize the composting efficiency.

Maintenance of the composting facilities include monitoring and adjusting moisture of the compost pile or heap. Periodically, samples of the composted material should be analyzed to determine the composting rate, and to optimize carbon amendment and moisture content. Equipment used to shred or apply carbon to the composting process should be maintained according to manufacturer recommendations.

### 8.2.3 Constructed Wetlands

Constructed wetlands can be the most cost-effective means by which nitrogen impacted groundwater may be treated. Ammonia is removed aerobically while nitrate is removed anaerobically. Therefore, a combination of surface and subsurface flow wetland systems appear to be the most efficient for treating combined ammonia and nitrate impacted groundwater. There is sufficient land available to maximize treatment residence times, diversify plant species, promote treatment even during the winter non-growing seasons, etc.

Bench or pilot scale testing is recommended best practice prior to proceeding with selecting engineered wetlands or a combination of these two as remedies for implementation at this Site. Parameters that should be assessed during a bench/pilot study for a wetland would be to looks at ammonia, nitrate and nitrite concentration in relationship to:

- Retention time
  - To be assessed by varying flow rate in a bench or small scale pilot study
- Orthophosphate concentration
- Oxidation reduction potential
  - To be assessed by measuring DO, ORP, total and dissolved Fe, dissolved methane, sulfate and looking at aerobic and anaerobic cells
- Organic carbon
  - To be assessed by measuring TOC

Oxidation reduction potential and organic carbon will vary according to the wetland matrix. Vegetation is also important but likely cannot be assessed in a bench or pilot study. A typical pilot study would use a minimum of 2 cells, one aerobic and one anaerobic. Variables to evaluate include flow rate (i.e., residence time) and a range of COC influent concentrations. Varying total organic carbon, phosphorus (or other) amendments would necessitate using more than two cells, but would provide a better dataset with respect to optimal organic carbon, phosphorus or other amendments of interest.

With respect to volatilization of ammonia, unionized ammonia (NH3) is volatile while ionized ammonia (NH4 or ammonium) does not volatilize. In typical dilute aqueous solutions with pH below 8, ammonium should predominate, with less than 10% of the ammonia available for volatilization.

Within the wetland, accumulation of microbial biomass will be promoted. Fouling within the groundwater extraction and conveyance systems will need to be addressed by physical cleaning methods as addition of biocides or antiscalants to control fouling will inhibit the beneficial microbial activity in the wetland. In the event pilot testing indicates the addition of amendments is needed to stimulate the removal of ammonia or nitrate, the amendments should be added near where the water enters the wetland to minimize fouling elsewhere in the extraction and distribution systems.

Maintenance of constructed wetlands will involve monitoring influent COC concentrations and water flowrate. At least quarterly, it is recommended that the constructed wetlands be inspected and correcting any areas where short circuiting of desired flow-paths may have occurred. It is recommended to perform routine quarterly inspection of all water recovery and conveyance systems and manually clean any biofouling or mineral scaling before these could result in unplanned system shutdowns.

#### 8.2.4 On-site Industrial Pre-treatment

Ammonia can be biologically oxidized in a two-step process first to nitrites and then to nitrates. This process can be duplicated by biological digesters. For large treatment plants, ammonia and nitrates are typically digested via activated sludge systems. However, biological systems require that the influent water is non-toxic to the biological media. For example, influent levels of ammonia on the order of less than 500 ppm are typically required. Further, biological systems require incubation time in order to reach (and monitoring to sustain) equilibrium. Lastly, attention must be given to the system as the environment must be maintained for the biological media to function. Disinfection of the effluent may be required.

In order to reduce nitrate, denitrifying bacteria need a sufficient carbon source. In conventional wastewater treatment, adding a carbon substrate is not necessary because the wastewater contains enough carbon for denitrification to occur. However, in the case of the on-site groundwater stream, there is no sustained source of available carbon for the denitrifying bacteria to use. An imported carbon substrate would need to be added (and perhaps re-added), and extensive testing would need to be conducted to determine if conditions are optimal for denitrification. A biological denitrification system would also require a large footprint to install and run. Thus, biological treatments were determined not to be feasible for use at the Site and removed from further consideration during the initial review of treatment technologies.

The combination of ammonia and nitrate in groundwater (along with other dissolved ions that will result in mineral deposits and scale) present a unique challenge to treatment by any on-site industrial waste water process. Unit operations to remove ammonia (air stripping) do not remove nitrates. Unit operations that remove nitrates (ion exchange and reverse osmosis) do not remove ammonia. A two-step biological process could be made to work, after bench testing and pilot testing. However, a constant supply of carbon would be a limiting factor in sustaining treatment for both compounds for the duration of the Site remediation.

Maintenance of the site-specific pre-treatment system will be dependent upon the actual processes that are included. The pre-treatment system would be designed to be as automated as possible. Telemetry would enable remote monitoring and allow for some remote adjustment to operating conditions. However, at a minimum, in-person site visits are recommended to prevent unforeseeable equipment failures or system upsets.

There appears to be sufficient area near the facility’s permitted outfall north of PW-9 to construct a building that would house the pre-treatment system. The system components would likely include: equalization or surge tanks, particulate filters, process tanks, transfer pumps, piping and electrical appurtenances, and control systems. A building to house a 300 gpm pre-treatment system might be approximately 30 feet wide by 50 feet long with a ceiling approximately 12 feet high.

#### 8.2.5 Off-site Sanitary Sewer Treatment

The City is planning upgrades to their waste water treatment works in order to meet more stringent nutrient reduction standards for nitrogen, among others. The date by which these upgrades may be made is projected to be sometime after the year 2023. Until that time, discharge of untreated groundwater to the City publicly owned treatment works (POTW) would result in no effective treatment for nitrate and ammonia removal while simultaneously adding an additional volumetric load to the treatment capacity of the POTW. Additionally, due to the ongoing documented mineral scaling currently experienced by the alluvial recovery wells, pumps and conveyance piping, similar operational complications are anticipated to drive the maintenance costs of this alternative to a prohibitive degree. If implemented, a costly sequestration or frequent preventive maintenance program would be required. Therefore, at this time, off-site sanitary sewer treatment was determined not to be feasible for use at the Site, and removed from further consideration during the initial review of treatment technologies.

#### 8.2.6 Farming

Approximately 30 acres of farmable ground exists on the Site adjacent to the south side of 1500 Road. While only seasonal, some of the groundwater might be used to irrigate crops within this parcel. To minimize the expense of farming and harvesting to the City, the parcel could be leased to a local farmer.

Maintenance of the infrastructure to irrigate farming areas will include inspections of piping, electrical, and fittings at routine intervals, or at least monthly. Repairs of infrastructure should be made early to prevent unscheduled interruptions to timely irrigation of crops. Soil samples will be required to analyze the pre-irrigation soil conditions and determine the maximum amounts of nutrients the irrigation water that can be applied without over-fertilizing the crops. Periodic analysis of the water quality will confirm that irrigation is benefiting the crops.

# 9. Preliminary Alternatives' Descriptions

The following sections describe preliminary engineering designs which were prepared to provide a basis for developing estimated costs for each remedial alternative. The following figures illustrate locations where the described alternatives might be deployed.

The No Action Alternative was retained for comparison purposes only. This alternative assumes no further monitoring or remedial activities will occur and that all monitoring and recovery wells will be abandoned and all existing remedial infrastructure and systems removed.

## 9.1 Sandstone Hill: Terraced Vegetated Cover (or Impermeable Cap), Constructed Wetlands, Ex-Situ Soil and Groundwater Composting

The area of the top of Sandstone Hill is approximately 15 acres (of which the AST containment basin occupies an estimated 2.4 acres) as illustrated on Figure 2.

Following the removal of AST #6, the secondary containment basin liner will be enhanced to maintain an impermeable cap. The basin will be converted into a receiving area for imported yard and tree debris (carbon sources for composting) and composting basin. The finished composted soil could be sold or given away to area gardeners, landscapers, etc.

Remediation of Sandstone Hill will involve rendering the nitrogen impacted soil unable to leach to groundwater and surface water. Contouring existing slopes by terracing will reduce the tendency for sheet flow precipitation runoff. Reduced sheet flow will reduce erosion and transport of impacted surface and exposed subsurface soil.

Likewise, adding a vegetated cover will promote uptake of both water and nutrients from the surficial soil and reduce the amount of water that may leach through, reducing the leaching of nitrogen into the sandstone aquifer. Vegetated covering for the west, south and eastern slopes are included in the preliminary design. Alternately, impermeable capping could be easily substituted for vegetated cover, with an eye maintained toward managing the increased storm water runoff as a result. The north and northwestern slopes of Sandstone Hill are thickly forested, so adding vegetation is unwarranted and unlikely to aide in remediation. Should sufficient precipitation reach impacted subsurface soil and seep out the side of the Sandstone Hill, the gentle slopes will help retain the seeps until the vegetation can uptake the nitrogen in the growing process. Water that is not reabsorbed or uptake by plants, will be directed to drain into the constructed wetlands on the south (in the Central Ponds area, discussed later) or east of the Sandstone Hill.

Constructed wetlands, strategically placed near natural drainage swales will aide in the treatment of groundwater seeps and precipitation runoff. Additionally, surface water that is collected in strategically located detention basins along the perimeter of the Sandstone Hill, could be pumped to the top of the Sandstone Hill for use in moisture control of composting soils that are excavated during terracing activities.

Alternate use of the AST #6 secondary containment basin were considered. The basin, once the AST #6 has been removed, could serve as an encapsulating cell for an estimated 40,000 cubic yards of excavated soil (or concrete rubble, or rebar debris). Once full, it could be impermeably capped with an impermeable or vegetated cover at grade and potentially re-developed.

## 9.2 Central Ponds: Terraced Vegetated Cover and Constructed Wetlands

The Central Ponds are situated within a narrow valley which slopes rather sharply downward from west to east. The entire area of the Central Ponds is estimated to be 5 acres as illustrated on Figure 3.

The slope will be terraced, to reduce the velocity and potential for erosion from precipitation runoff and sheet flow. Excavated soil will be added to the soil composting operation in the AST containment basin on top of Sandstone Hill. It is assumed that the valley terracing will expose consolidated sandstone. Precipitation falling on the exposed rock surface will cascade and aerate as it tumbles into a new 1-acre pond to be constructed at the east end of the valley. The two interception trenches will continue to capture groundwater which may seep from the hillside and gather in the new pond. Over time, sediments will accumulate and aquatic plant species (e.g. cattails) will eventually establish or be introduced. In the event of unusual precipitation events, the pond may overflow into the additional constructed wetlands to be installed in the Eastern Ponds area (as discussed later).

Due to the comparatively high concentrations of ammonia in groundwater on Sandstone Hill and within the Central Ponds, it will be important to combine any remedy for the Central Ponds with capping or covering to limit recharge of the groundwater seeping into the Central Ponds from Sandstone Hill in order to control/minimize off-gassing of ammonia from groundwater emanating from that area.

Due to the comparatively high concentrations of ammonia in the soil and groundwater in this area, redevelopment considerations should include vapor migration mitigation measures such as impermeable composite membranes to enhance capping or installing negative pressure vapor extraction and emissions treatment system.

## 9.3 Plant A: Impermeable Cap and Ex-situ Soil Composting

The area of Plant A, as illustrated on Figure 4, is approximately 15 acres. Currently, although not complete and with some gaps between asphalt and concrete covers where soil is exposed, the entire surface are of Plant A is mostly capped with a combination of asphalt and concrete pavement and remnants of old building and process equipment foundations. Analytical data show that both soil and groundwater in this area contain concentrations of nitrogen above remedial action goals. Enhanced capping activities would involve filling significant voids, and exposed concrete channels, then overlaying asphalt or concrete in varying thicknesses to restore the surface to a uniform grade.

If, in the future, development of this area may be envisioned, geotechnical evaluations of the suitability of the underlying soil to support building would be prudent. Conversely, if the suitability of the area is dependent on the removal of existing surface cap materials, then the replacement of that cap would be accomplished with the erection of a new surface structure of choice.

Should soil require excavation to facilitate construction of subsurface utilities or building foundations and footings, the excavated soil could be segregated from the overlying cap, and added to soil composting activities atop Sandstone Hill.

## 9.4 Western Ponds: Vegetated Cover, Ex-situ Soil Composting, and Constructed Wetlands

The Western Ponds (Krehbiel, Old West, and West Extension), shown on Figure 5, are approximately 3.1 acres in total area. The location at the base of Sandstone Hill receives uncontrolled precipitation runoff from the north slope of the Sandstone Hill. In addition, assessment data indicates that historical operations have resulted in nitrogen impacts to soil and groundwater. Soil in this area is silty clay overlying low permeability sandstone. The groundwater within the sandstone is low yielding and not ideal for groundwater extraction. The estimated costs for this alternative is presented in Table 8.

Re-grading the area to direct runoff from the Sandstone Hill and surrounding areas into the ponds would allow for treatment by constructed wetlands. Treated runoff would be directed into the Regional Detention Basin of allowed to percolate into the underlying groundwater unit. Excess soil generated from the re-grading activities could be composted on top of Sandstone Hill. After regrading and constructing wetlands, the surrounding ground surfaces would be revegetated to minimize further runoff.

## 9.5 Eastern Ponds: Constructed Wetlands, Excavated Soil Composting, Farming, Capping, and Vegetated Cover

The Eastern Ponds (West Lime, Rundown, Overflow, and East Lime) occupy approximately 23.1 acres, as shown on Figure 6.

Groundwater recovered from the alluvial recovery wells, and surface water runoff overflows, will be directed to this area. Constructed surface and subsurface wetlands could accommodate large volumes of nitrogen laden groundwater and surface water. Wetlands are typically constructed with low permeability bottoms (liners) to minimize leakage and loss. The recent geotechnical data from the DGS indicates the pond bottoms will not need additional clay in order to meet the "low permeability" requirement.

Soil excavated from the Central Ponds and wastes generated from lime softening operations are also located in this area. Prior to constructing wetlands, this soil should be added to the composting on top of Sandstone Hill. The remaining area could be regraded to maximize residence time of the overflow surface water from Central Ponds and the Western Ponds plus recovered groundwater from the hydraulic containment system.

Using the Eastern Ponds as an encapsulating cell for all excavated soil on-site was considered. Excavated soil could be interred within the existing ponds after removing the water that is still remnant from the previous storage activities. Capping, farming and/or vegetated covering would be accomplished as previously described.

## 9.6 Bag Warehouse: Impermeable Cap and Soil Composting

As shown on Figure 7, the entire area of the Bag Warehouse plus the paved area directly east, is approximately 3.6 acres. As the Bag Warehouse serves as a competent impermeable cap and the paved area also is effectively impermeable, no additions or modifications should be required to cap this area. Should any new construction be performed, nitrogen-impacted soil excavated as result could be added to composting elsewhere on the Site. The Bag Warehouse structure would require routine maintenance and upkeep to preserve the structural integrity of the building.

## 9.7 Site-wide Alluvial Groundwater: Composting, Constructed Wetlands, On-site Industrial Treatment, and Off-site Sanitary Sewer

Hydraulic containment of the alluvial aquifer is an ongoing centerpiece of the Site-wide groundwater remediation strategy. The future strategy however, as directed by the new operating and DGS data, is shifting west. New proposed recovery wells will be installed between PW-9 and PSW-3B. Pumping rates in individual recovery wells will increase from the previous design of approximately 25 gpm, to approximately 50 gpm. With four recovery wells each pumping 50 gpm, the designed maximum is 200 gpm. Additional treatment capacity needs to account for supplemental overflow during storm events. Therefore a design maximum continuous operating flow rate of 300 gpm was used as the basis for cost comparisons.

One of the possible design configurations is illustrated on Figure 8 and is used as the basis for cost estimating. Several options were considered for the onsite treatment of recovered groundwater. The options that are described in this section include:

1. Constructed wetlands – the area exists in the Eastern Ponds to accommodate more than the design flow rate of 300 gpm. Existing piping is present, however, an equalization basin would be added near PW-9 and larger lift stations would replace the North and Southeast Sumps.
2. On-site industrial treatment by two-step biological treatment – the on-site treatment system would have capacity to treat 300 gpm. However, bench and pilot testing would precede final design. The waste stream from the treatment system would be low in nitrogen, but other minerals and nutrients may be unacceptably high for discharge directly to the nearby drainage ditch, which in turn discharges directly into the Kansas River. Inorganic analyses of groundwater for the Site are summarized in Appendix C. According to the inorganic data, the water quality is considered to pose complications from precipitation and hardness. Pre-treatment for potential fouling may reduce this potential, however, capital and maintenance costs will need to be increased accordingly, depending on the findings from bench testing before full-scale design and implementation.
3. Discharge to surface water without treatment – Pumping 300 gpm directly to the surface water drainage ditch without treatment, but while complying with all the terms of the NPDES permit, is not typically a favorable public or regulatory alternative.
4. Discharge to sanitary without treatment – Pumping 300 gpm directly to the nearest sanitary sewer lift station, while convenient, is not without cost or consequence. The cost includes mandatory upgrades to the lift station, increased monitoring and highly automated controls. Consequences include impacting the capacity of the POTW to treat 300 gpm of low-carbon containing groundwater, while displacing the like capacity from residential and business customers.

# 10. Remediation Cost Estimates

This section discusses the assumptions and rationale used to estimate comparative costs for each of the previously described alternatives. The estimated cost for each alternative is summarized in Table 4 through Table 11d.

The No Action Alternative was retained for comparison purposes only. This alternative assumes no further monitoring or remedial activities will occur and that all monitoring and recovery wells will be abandoned and all existing remedial infrastructure and systems removed. The estimated cost to implement this alternative is summarized in Table 4, and the total cost estimated is: $643,000.

Certain necessary assumptions were taken into consideration to prepare these preliminary estimated costs based on the conceptual designs presented in this C-BA. The assumptions are listed on the individual tables, and are re-stated here for emphasis:

**Cost Estimating Assumptions:**

- Costs have been estimated in 2020 dollars based on GHD's experience with similar sites in similar settings.
- Cost estimating was performed for the projected life of each alternative of 30 years. The estimating method and discount rate of 7% to determine the net present value of each were taken from the following: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
- Costs assumed design occurs in year 1, construction occurs in year 2, followed by inspections/maintenance in years 3 through 30.
- As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.
- At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.
- Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.
- Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.
- During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.
- Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once designed and final power requirements are known, supplemental or substitute sources of energy such as wind and solar should be evaluated and may be more economical.

## 10.1 Sandstone Hill: Terraced Vegetated Cover/Impermeable Cap, Constructed Wetlands, Ex-Situ Soil and Groundwater Composting

Costs for this alternative are summarized in Table 5. Because the cost for composting is estimated prior to the performance of bench or pilot testing, several variables to the execution of this treatment alternative remain in question. Composting is a very low energy input effective means to remove nitrogen as its elemental gaseous form. The final product should be suitable for use as fill onsite or as landscaping and garden amendments off-site. Among the operating variables to sort out during the detailed design phase:

- The volume of water necessary to achieve and maintain optimum moisture content.
- Shredding tree and yard debris requires the purchase, lease or rent of specialized industrial capacity equipment. The investment in which would help to minimize the effect of heterogeneity in the carbon source and increase the surface area to maximize contact between carbon, nitrogen and water in the composting process.
- Impermeable capping could be used to supplement or replace the vegetated cover. In areas where impermeable capping is used, allowances would be needed in the design to manage increased storm water runoff.

## 10.2 Central Ponds: Terraced Vegetated Cover/Impermeable Capping and Constructed Wetlands

Costs for this alternative are summarized in Table 6. Surface conditions in the immediate vicinity of the Central Ponds sump area are reportedly perennially wet. It is with that in mind and the knowledge that the Central Ponds interception trenches recover nitrogen impacted groundwater year-round, that a large (approximately 1 acre) pool is proposed for the east end of the Central Ponds valley. The pool will be over excavated to an average depth of 5 feet to add capacity to hold runoff during large rain events. Soil resulting from the excavation/construction of the pond and wetlands will be composted.

Impermeable capping could be used to supplement or replace the vegetated cover. In areas where impermeable capping is used, allowances would be needed in the design to manage increased storm water runoff.

## 10.3 Plant A: Impermeable Cap, Ex-situ Soil Composting

Costs to implement this alternative are summarized in Table 7. The existing cap may need minor repairs or patches, however, the overall quality of the cap is assumed sufficient to minimize surface infiltration. A modest allowance was included in the event incidental soil requiring composting is generated.

## 10.4 Western Ponds: Vegetated Cover, Ex-situ Soil Composting, and Constructed Wetlands

Costs to implement this alternative are summarized in Table 8. While the Western Ponds can be reconfigured through surface grading to accommodate wetlands, the fact that the surface and subsurface soil in this area is impacted with comparatively higher nitrogen concentrations, will complicate their operations. Construction of the bottoms of these ponds is unknown. If the bottoms are constructed of something other than low permeability clay, they may need to be drained and lined once their true construction becomes apparent.

## 10.5 Eastern Ponds: Constructed Wetlands and Excavated Soil Vegetated Cover

Costs for this alternative are summarized in Table 9a and 9b. This scenario was approached as the entire 23.1 acre-area converted to wetlands and a second scenario (Table 9b) as 18 acres of wetlands and 5.1 acres of East Lime Pond as a vegetated cover landfill.

## 10.6 Bag Warehouse: Impermeable Cap and Soil Composting

Costs estimated for this alternative are summarized in Table 10. Similar to Plant A, this area should require very little by way of improvements to enhance the impermeability of the current warehouse and the adjacent paved areas.

## 10.7 Site-wide Alluvial Groundwater: Composting, Constructed Wetlands, On-site Industrial Treatment, Off-site Surface Water Discharge and Off-site Discharge to Sanitary Sewer

Costs estimated for this alternative are summarized on Table 11a, Table 11b, Table 11c, and Table 11d. Adding recovery wells will increase the amount of water requiring treatment, but will also assist in keeping concentrations of nitrogen in the recovered groundwater low to allow for a wider selection of potential treatment and disposal options.

Table 11a summarizes the costs for the least costly alternative for disposing of all recovered groundwater and storm water to the NPDES-permitted outfall onsite. This alternative does not meet all of the Site-specific RAOs, but allows for controlling the final discharge concentrations of nitrogen compounds to within permitted limits. This option was estimated to cost $661,000.

Table 11b summarizes costs estimated for treating water (groundwater and storm water) while achieving all of the RAOs by converting the area overlying the former Eastern Ponds to constructed wetlands. This option was estimated to cost $1,052,000.

Table 11c summarizes costs estimated for treating water (groundwater and storm water) while achieving all of the RAOs by installing and operating a pre-treatment system to achieve all NPDES-permitted surface water discharge criteria. This treatment system would necessitate bench and pilot testing due to the presence of inorganic constituents such as sulfate, iron, and calcium, which will complicate ammonia and nitrate destruction. Addressing the water quality prior to treating for the COCs will result in the waste byproduct stream requiring separate storage, handling and disposal. Cost for this scenario are estimated to be $ 8,877,000.

Table 11d summarizes costs estimated for discharging all untreated water (groundwater and storm water) while achieving all of the RAOs directly to a nearby (~1,000 feet East) sanitary sewer lift station. This option, while not currently available, achieves the RAOs. However, the City has no current plan or schedule to upgrade the POTW, so this option will require re-evaluation when that plan and schedule are known. Cost for this scenario were estimated to be $1,962,000.

# 11. Remedial Alternative Comparisons

This section discusses the alternatives comparison presented in Table 12. Each alternative was evaluated qualitatively using four criterion: cost, compliance with remedial action objectives, long-term effectiveness and implementability. Cost stood alone while the other three were scored on a scale from 0 to 10 (0 being the least favorable and 10 being the most favorable).

According to its preliminary design, remediation of Sandstone Hill would cost an estimated $1,191,000. The compliance with RAOs, long term effectiveness and implementability were scored 9, 8 and 9. Options to composting soil created from terracing do exist, including on- and off-site landfilling. Both of these options may be less costly, but soil disposed on-site without treatment, will occupy real estate that may eventually be needed for development. The cost for off-site disposal of excavated soil was not considered economically viable given the sizable area of the Site for composting and re-use as regrading and backfill of composted soil.

According to the preliminary design, remediation of the Central Ponds would cost an estimated $850,000. Excavation of nitrogen impacted soil in this area will expose consolidated sandstone. The excavated soil will require treatment. The relative score was for compliance with RAOs, long-term effectiveness and for implementability were 8, 8 and 7, respectively. The design relies on groundwater to continue seeping into the pond. In the event recharge to the Sandstone Hill aquifer is successfully curtailed by the capping/covering on top of the Sandstone Hill, additional water from the alluvial hydraulic containment system may be diverted to the Central Ponds area.

Costs for remediating Plant A and the Bag Warehouse areas are similarly designed. Remedial action at Plant A was estimated to be $708,000. Costs for remediating the Bag Warehouse area is estimated to be $304,000. It is important to note the difference between these costs is primary due to the presence of a large pile of concrete rubble and rebar debris at Plant A. Also, the Bag Warehouse area is smaller (3.6 acres at the Bag Warehouse and 15 acres at Plant A). Capping at both locations, with open access for repairs and maintenance. Allowances were made in both cases to address incidental amounts of excavated soil by composting.

Western Ponds remediation is estimated to cost $464,000. This area is barely 3 acres. Constructing wetlands and performing a modest level of surface restoration may result in a small amount of soil for composting. Additional expense may be needed in order to line the ponds with clay or a polymer material to prevent leakage that could result in undesirable transport of nitrogen from the soil beneath the existing ponds.

The Eastern Ponds remediation is estimated to cost of $935,000. This is estimated based on all 23.1 acres converting to wetlands. If the East Lime Pond were converted to a landfill instead, the cost to remediate the Eastern Ponds is estimated to be $1,016,000. Both score 9 on compliance with RAOs and 9 on the long-term effectiveness. Implementability is slightly easier for converting all the land to wetlands. Constructing an encapsulation cell in the East Lime Pond is slightly more challenging, since all efforts to prevent future breaches must be made. Also, converting land into a landfill will remove it from future re-development opportunities.

The recommended remedy for site-wide groundwater hydraulic control and treatment using constructed wetlands was estimated to cost $1,052,000 over 30 years, with an average evaluation score of 8. Other alternatives are listed with the on-site industrial pre-treatment scenario estimated to cost $8,877,000. Discharge to the POTW is estimated at $1,962,000. Discharge directly to the surface water without treatment is estimated to be $661,000. All three means of remediation scored 9 for long-term effectiveness. However, under implementability, the highest score was converting Eastern Ponds to wetlands and NPDES-permitted discharge directly to surface water. The City has not yet converted their POTW to treat groundwater for the removal of nitrogen. Design of the pre-treatment system will require extensive testing and development, and generate a byproduct waste stream that will need to managed, stored and disposed.

# 12. Conclusions and Recommendations

Based on the foregoing analysis the recommended alternatives are as follows:

- Sandstone Hill – Vegetated cover, soil compositing, constructed wetlands. Controlling the infiltration and runoff of storm water on Sandstone Hill will reduce significantly the transport of nitrogen into the groundwater and surface water emanating from it. Due to the substantial volume of the Sandstone Hill, the anticipated mass of nitrogen contamination within the various layers of lithologic strata, and the uncertainty of fracture-flow present in the sandstone aquifer, pumping groundwater or injecting nutrients or chemicals to enhance biological or chemical degradation is not technically feasible or practical. Total estimated cost is $1,191,000.
- Central Ponds – Constructed wetlands, soil composting. Due to the Central Ponds location, excavating contaminated soil from this area has already proven once to be an ineffective means of reducing groundwater re-contaminating clean backfill used to restore the area. A series of terracing, constructed wetlands, and composting excavated soil, would seem the most practical approach. Total estimated cost is $850,000.
- Plant A – Impermeable capping. The area that was Plant A is mostly capped and would need a minimal amount of additional effort to seal gaps where the cap is observed to be incomplete. Preserving the cap could also be accomplished by redeveloping this area with permanent above ground structures equipped with roof drains to convey storm water to the nearby “clean” regional detention basin. Total estimated cost is $945,000.
- Western Ponds – Wetlands. The Western (and Eastern) Ponds are suitably located and sized to accommodate constructed wetlands necessary to treat the recovered groundwater generated during hydraulic control and containment operations. Total estimated cost is $464,000.
- Eastern Ponds – Wetlands. The Eastern (and Western) Ponds are suitably located and sized to accommodate constructed wetlands necessary to treat the recovered groundwater generated during hydraulic control and containment operations. Total estimated cost is $935,000.

- Bag Warehouse – Impermeable capping. Generally, the Bag Warehouse, due to its size, accomplishes most of the capping needed to prevent infiltration of precipitation in this area. There are some residual surfaces surrounding the Bag Warehouse that would need supplemental capping added at a minimal effort and cost. Total estimated cost is $304,000.
- Site-wide Groundwater – Hydraulic control, with treatment via wetlands in the Western and Eastern Ponds. Hydraulic control near PW-9 and PSW-5B2 is still needed to safeguard off-site migration of nitrogen impacted groundwater from leaving the Site at concentrations above remediation goals. Sufficient land is available in the Western and Eastern Ponds, which could be supplemented by wetlands added on the slopes of Sandstone Hill, at the east end of the Central Ponds and by reconfiguring the Krehbiel and Old West Ponds. Total estimated cost is $1,052,000.

Approval of final remedial strategy(ies) will change the terms and conditions of the Department of Agriculture term groundwater recovery and storage permits, the National Pollutant Discharge Elimination System (NPDES) permit, and the long-term care agreement (LTCA) necessary to comply with current and future Environmental Use Controls (EUCs) for the Site.

Following the submittal of this C-BA the following sequence of events is anticipated:

1) Based on GHD's evaluation, the recommended corrective actions for the Site will include:
   a. In coordination with any redevelopment of the Site, capping areas of the Site using permeable and impermeable surfaces and dedicating areas of the Site to re-use as constructed wetlands. Surfaces where contaminated soil exists should be covered to the maximum practical extent and recovery of contaminated groundwater should be optimized to control off-site migration of impacted groundwater while minimizing the volume of recovered groundwater requiring treatment. Constructed wetlands appear to be the most cost-effective technology for treating recovered groundwater; however, bench and/or pilot testing this technology is necessary to determine the design, operation and maintenance sensitivities to mineral and contaminant concentrations. At such time as it may be both available and feasible, discharge of some (if not all) of the recovered groundwater to the City of Lawrence sanitary sewer system for biological nutrient removal appears an attractive technology worthy of further review in the future.
2) The KDHE will review and ultimately approve the C-BA and recommended remedial alternatives with contingencies.
3) The City will develop a Remedial Action Plan (RAP) that will include:
   a. Establish new remedial action goals.
   b. Plans for installing, testing, operating and maintaining recovery wells to hydraulically control areas of groundwater containing nitrogen at concentrations above remedial action goals.
   c. Plans for bench and/or pilot testing of constructed wetlands and composting.
4) The KDHE will approve the RAP.
5) The City and KDHE will renegotiate new or revised Consent Order, Corrective Action Decision (CAD), NPDES permit, and groundwater use permits.

6) The City will submit a new revised Corrective Action Plan (CAP) detailing proposed bench or pilot testing for industrial pre-treatment processes, composting soil and groundwater, and constructing and operating wetlands, new recovery well locations and construction, and interim plans for water management until such time as a more permanent treatment and discharge remedy is determined and approved.

7) The KDHE will approve the CAP

8) The City will implement the approved CAP.

# 13. References


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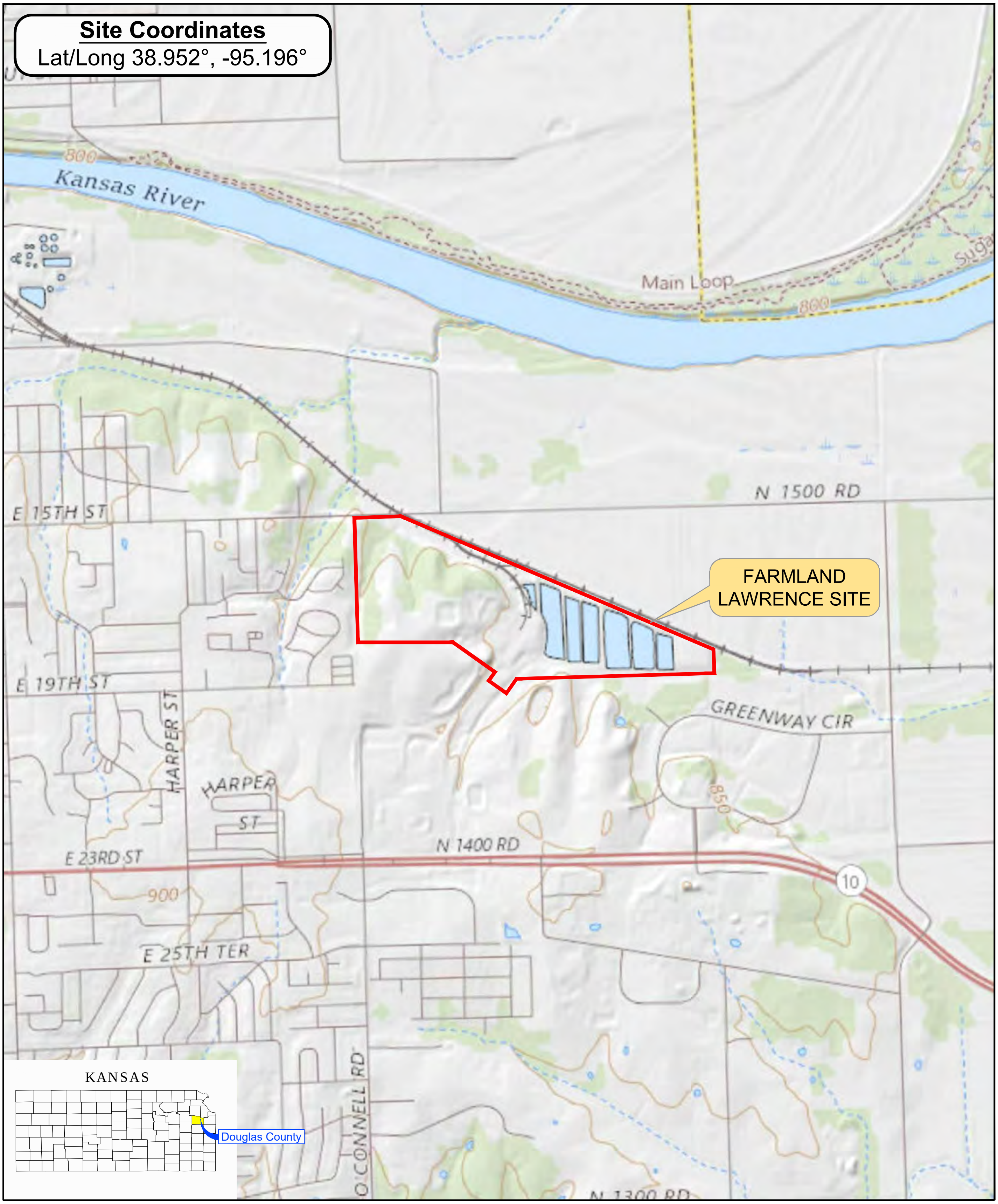
# Figures




Source: USGS 7.5 MINUTE QUAD "LAWRENCE EAST, KANSAS"

0 1000 2000ft

Coordinate System:
STATE PLANE -
KANSAS SOUTH

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FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02

Mar 13, 2020

SITE LOCATION MAP

FIGURE 1

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 200 400ft

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GHD

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

FARMLAND REMEDIATION SITE LAYOUT

11152783-02
May 12, 2020

FIGURE 2

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 50 150ft

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES
SANDSTONE HILL

11152783-02
May 12, 2020

FIGURE 3

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 40 120ft

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FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES
CENTRAL PONDS

11152783-02
May 12, 2020

FIGURE 4

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 40 120ft

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES
PLANT A

11152783-02
May 12, 2020

FIGURE 5

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

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FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES - WESTERN PONDS

11152783-02
May 12, 2020

FIGURE 6

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 50 150ft

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES
EASTERN PONDS

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May 12, 2020

FIGURE 7

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 50 100ft

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FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL LOCATIONS OF REMEDIAL ALTERNATIVES
BAG WAREHOUSE

11152783-02
May 12, 2020

FIGURE 8

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Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

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GHD

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
COST BENEFIT ANALYSIS REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

POTENTIAL CONFIGURATION - SITE-WIDE GROUNDWATER RECOVERY, DISTRIBUTION AND MONITORING WELLS

11152783-02
May 22, 2020

FIGURE 9

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(003)CostBenefitAnalysis\11152783-02(003)GN-DL001_CBA.dwg

# Tables

**Table 1**
**Summary of Maximum Nitrogen Concentrations in Groundwater**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Area | Total Nitrogen in Soil (mg/Kg) | |
|---|---|---|
| | Surface | Subsurface |
| Bag Warehouse | 500 | 500 |
| Central Ponds | 5,000 | 5,000 |
| Eastern Ponds | 1,000 | 1,000 |
| Former Plant A | 5,000 | 5,000 |
| Sandstone Hill | 1,000 | 1,000 |
| Western Ponds | 5,000 | 5,000 |

**Table 2**
**Summary of Maximum Nitrogen Concentrations in Groundwater**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Area | Nitrate as N Groundwater (mg/L) |
|---|---|
| Bag Warehouse (DGS data needed) | 344 |
| Central Ponds, at CPMW-1D | 17,300 |
| Eastern Ponds (DGS data needed) | 10,900 |
| Former Plant A, at PSW-13A | 350 |
| Sandstone Hill. At N-1 | 11,300 |
| Site-Wide Groundwater, at PW-9 | 27 |
| Western Ponds, North Sump | 2,280 |

**Table 3**
**Summary of Screened Remedial Technologies**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Technology | Description | Effectiveness | Implementability | Relative Cost | Screening Comments | Retained (Yes/No) |
|---|---|---|---|---|---|---|
| **Soil** | | | | | | |
| Impermeable Capping | Impermeable capping materials are typically polymer membranes, clay, pozzolanic cements mixed with native soil then hydrated, concrete or asphalt May require a sublayer of permeable material to serve as a drainage layer to convey groundwater or water that seeps through seams or gaps in the overlying impermeable cap. | Effective at reducing leaching due to precipitation, but does not prevent impacted soil from the influence of fluctuating groundwater | Usually requires significant labor and equipment and pre-design. Requires a drainage layer installed between the capping material and the material being capped. The water drained by the drainage layer usually becomes contaminated, thus requiring special handling. | moderate to low. Less costly when combined with other site re-development activities necessitating installation of parkling lots and buildings. | Capping requires maintenance and the material being capped is not undergoing active or passive remediation while capped. | **Yes** |
| Vegetated Covering | Permeable cover that uses precipitation to establish and sustain vegetation. | Very effective in using the precipitation for growth allowing very little or no leaching of contaminants from the soil being covered. | Typically easy to implement. Severe slopes are typically terraced to minimize runoff and promote some infiltrations needed to sustain plant growth. | low. May be more effective when combined with rasing crops or aesthetic landscaping in conjunction with site re-development. | Highly desirable for covering soil contaminated with fertilizer, because the nutrients in the soil may eventually become soluble and used by the vegetation. | **Yes** |
| Composting | Mixing organic matter, media contaminated with nutrients (i.e., nitrogen), and water mixed in the right proportions to promote an almost self-sustaining process. | Very effective to degrade nitrogen and generate an end-use material suitable for re-use as landscape fill or for amending soil for gardening. | Bench testing is advised, however, once the right proportions are determined, and off-site sources of organic matter identified, the Site has more than adequate area to accommodate a composting process. | low to moderate. May be significant upfront capital investment for commercial-duty wood shredder. But ongoing operating costs are low and periodic to maintain optimum moisture and nutrient content of compost piles or heaps. | Green remedial technology with a beneficial end-use product. | **Yes** |
| Land Application/Farming | Farming involves identifying a cash crop suited for the terrain and climate. | Only limited benefit as not enough farmable land exists on the property | Easy to implement once agronmic analysis determines the amounts and types of amendments to augment the existing soil. | Low once upfront capital investment to install delivery infrastructue. | green remedial approach but limited to farmable land on-site. | **Yes** |
| Constructed Wetlands | Wetlands utilize natural bacteria to degrade or metabolize nutrients in nitrogen-impacted soil or groundwater. | Can be very effective in removing both ammoni and nitrate ntrogen, but in a two stage process. May not be able to treat all soil resulting from terracing activities. | straightforward implementation when suitable lowlying property of adequate size is present. | low to moderate. Constructed wetlands, while proven to remove nutrients from waste streams, will require bench or pilot scale testing to determine optimum flow rates, contaminant concentrations, potential conflicts with other inorganic compounds that may not be subject to removal via biological degradation mechanisms. | green technology that also provides wilflife habitat while performing remediation. | **Yes** |
| Excavation for off-site disposal | Excavating soil and disposing in a licensed landfill. | Can be effective in cases where soil contamination is not wide-spread or where it is confimned to depths easily accessible to conventional excavting equipment. | Excavate and haul. Complications arise when contaminated soil is excavated from directly above or within contaminated groundwater regimes. Post-excavation fluctuating groundwater elevations will re-contaminate clean backfill. | Moderate to high. Excavation and loading are typically the lower cost inputs for this technology. Transport and disposal of the excavated material and imporing clean suitable backfill to restore excavations tend to make this technology potentially very high cost. | Requires characterization of the soil as waste, documentation to and interment in, the off-site repository, and the responsible party typically retains all future liability associated with the waste. | No |
| Stabilization, solidification | Pozzolonic or other solidfying compounds are actively mixed with the soil to form a rigid solid matrix that serves as both a capping layer and to eliminate the potential for leaching contamination by infiltrating precipitation. | Effective in mitigating leachability of contaminants from within the stabilized soil layer. Ineffective in removing or immobilizing contaminatio in soil below the stabilized layer or within the groundwater regime. | Typically easy to implement in the upper few feet of the soil layer. Implementation becomes problematice in deep soil stabilization in areas where severe slopes or consolidated rock is present, | Low to moderate. Costs for maintenance depend on the durability of the stabilized layer to stand up to freeze/thaw cycles and rising groundwater elevations. | Typically only applicable to the upper layer of impacted soil. Groundwater elevations may rise and cause strresses on the stabilized layer, resulting in cracks which allow future precipitation infiltration. | No |

**Table 3**
**Summary of Screened Remedial Technologies**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Technology | Description | Effectiveness | Implementability | Relative Cost | Screening Comments | Retained (Yes/No) |
|---|---|---|---|---|---|---|
| **Groundwater** | | | | | | |
| Hydraulic Containment | Strategically located pumping wells exert influence laterally and downgradient on contaminated groundwater that would otherwise migrate off-site is controlled and treated or managed onsite. | Very effective in reducing the mass of contaminats in the groundwater and in containing contamination to onsite, thus reducing potential for third party liability. | Two or three new recovery wells should be installed and additional monitoring wells to improve the data gathering resolution of hydraulic influence and COC concentration. Most of the infrastructure required is in place. | Low to moderate | With minor modification to the current containment systems and installation of redundant groundwater treatment methods, this techology seems well suited for this Site. | **Yes** |
| Constructed Wetlands | Wetlands utilize natural bacteria to degrade or metabolize nutrients in nitrogen-impacted soil or groundwater. | Can be very effective in removing both ammoni and nitrate ntrogen, but in a two stage process. The Site appears to have ample available land to install constructed wetlands. | Following successful bench and/or pilot testing, the area appears to be available to accommodate this approach. Grading low-lying areas where water conveyance structures are currently located should simplify implementation. | Moderate | The Site appears to be adequately sized to accommodate constructed wetlands, following successful testing to determine optimal design criteria.. | **Yes** |
| Composting | Mixing organic matter, media contaminated with nutrients (i.e., nitrogen), and water mixed in the right proportions to promote an almost self-sustaining process. | Very effective to degrade nitrogen and generate an end-use material suitable for re-use as landscape fill or for amending soil for gardening. Requires bench/pilot testing to determine Carbon:Nitrogen:water ratios. | Following successful bench or pilot testing, this technology would still require import of significant, if not daunting, quantities of carbon in order to treat the estimated 300 gpm for this Site. | Low to moderate | Requires significant quantities of carbon, and area to manage composting facilities. | **Yes** |
| Land Application/Farming | Farming involves identifying a cash crop suited for the terrain and climate. | Only limited benefit as not enough farmable land exists on the property. Also, irrigating crops is a seasonal activity and does not occur during the non-growing season. | Irrigation during growing season only. | Moderate | Best for growing season. | **Yes** |
| Industrial Treatment (discharge of treated water to either surface water to sanitary) | Involves constructing operating and maintaining a process system to destroy the COCs and disharge the treated water to either the surface water or sanitary sewer under terms of an appropriate permit. | Can be very effective, however, results in siognificant quantities of undesirable waste byproducts requiring either disposal or further treatment, then disposal. | This will require dedicating a significant area near the current outfall to accommodate the treatment system building, dedicated electrical power supply, and storage areas for raw materials and waste byproducts. Operation, mintenance and monitoring of this system could be complex. | High | retained for comparison pruposes, however, managing raw materials to manipulate pH and disposal or after-market of waste byproducts increase maintenance and operating costs. | **Yes** |
| Discharge to Surface Water without Treatment | This would allow discharing to the surface water (ultimately to the nearest receiving stream : the Kansas River) under terms of a NPDES permit without treatment. | Can be very effective, while transferring the COCs to the downstream receiving water. | With the addition of recovery and monitoring wells, re-routing some piping, and removing on-site storgae, no additional changes to the current strategy would be needed. | Low | This option is well suited by its rural setting, as long as monitoring of the dischrage shows all reglulated constituents remain below permitted limits. | **Yes** |
| Discharge to Sanitary Sewer without Treatment, at a future date | This would require connecting the recovery wells to the sanitary sewer and pumping directly to the sewer without treating the water. | If in the future, the City upgrades will accommodate additional capacity, this option couyld be very effective at removing the COCs. | Connecting to the nearby (~1,000 feet East) sanitary sewer lift station, significant maintenance of anticipated fouling, and must follow the City's upgrades of the WWTP to remove nutrients. | Moderate - involves increased maintenance for conveyance and electrical systems. | in terms of ease of implementation, if at some point in the future the City's POTW can accommodate it, this option is easiest behind discharging to the surface water without treatment. | **Yes** |
| Industrial scale ammonia stripping | Industrial scale stripping of volatiile ammonie requires adjusting the solution pH, using air stripping to remove the gaseous phase ammonia, followed by neutralizing the pH. | Can be effective, while transferring the ammonia in the gaseous phase to the atmopsphere, thus poitentially creating an airborne nuisance or health hazard. | Difficult. Likely would increase airborne concentrations of ammonia requiring an evaluation for an air permit and may necessitate ammonia off-gas recovery and disposal. | High | the manipulation of the pH to enhance stripping and neutralization of the water, before the nitrate is even addressed, renders this an overly complicated, expensive, and waste generating option to avoid | No |
| Industrial scale evaporation | This technology is energy intensive and uses heat to evaporate the water, leaving a concentrated solution of nitrate, ammonia, and all the non-volatile inorganic consitituen ts present in groundwater. | Can be very effective. However, the more concentrated the solution becomes the gretarer the potential for its chemistry to change and the final waste byproduct, while rich in ammonia and nitrate, may also be rich in less desireable constituents reuiring special waste handling and disposal. | The energy requirements for this option would be significantly higher than any of the other options screened. | High | Waste byproducts likely unusable as a market5able commodity | No |

**Table 3**
**Summary of Screened Remedial Technologies**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Technology | Description | Effectiveness | Implementability | Relative Cost | Screening Comments | Retained (Yes/No) |
|---|---|---|---|---|---|---|
| **Groundwater** | | | | | | |
| In-situ enhanced reductive denitrification | This requires injecting soluble electron donor solution of carbon or other compound. The degree of success relies on intimate prolonged contact between injectant and the contaminated groundwater. Treatment is effected by reaction between the COCs and the electron donor. | Not very effective in fractured lithologic aquifers. May be effective in low or moderately transmissive aquifers. | Implementing this technology in fractured formations typically yields unreliable and unfavorable results. IN areas where the groundwater gradient is generally flat, the groundwater velocities are too low to ensure intimate contact between injectant and COCs. | High | Typically requires muiltiple injections over the course of several years for similar volumes of contaminated groundwater/ | No |
| Permeable Reactive Barrier (PRB) | Involves constructing a wall of highly permeable reactive media at depths that span the entire vertical thickness and width of the contaminated groundwater plume. COCs are destroyed or removed as the groundwater migrates through the "wall". | Requires continually monitoring to be sure the wall is not short-circuited or otherwise bypassed by the contamination. Reactive media may require replacement or augmentation or cleaning/replacement depending on the degree of biomass accumulating within it over time. | Very difficult, Depth to groundwater is approximately 30 feet, the impacted front of the groundwater plume is at least 30 feet thick, and the width of the groundwater impacted by nitrogen exceeds 2,000 feet. Walls of this magnitude are very difficult to properly construct. | Very High | Due to the extreme magnitude of this technology compared to others, it was not considered further. | No |

**Table 4**
**Cost Estimate for Remedial Alternatives: No Action Alternative**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** The No Action Alternative is used for comparison purposes only. This alternative assumes no further monitoring or remedial activities will be performed and that existing monitoring networks and remedial infrastructure and systems will be abandoned or removed.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Decommission/Salvage Tank #5 and Tank #6 | 1 | lump sum | $ 200,000 | $ 200,000 |
| Monitoring and Recovery Well Abandonment | 1 | Lump Sum | $ 50,000 | $ 50,000 |
| Interception Trench Decommissioning | 4 | trenches | $ 25,000 | $ 100,000 |
| General site regrading with existing on-site soil and materials. | 1 | Lump Sum | $ 200,000 | $ 200,000 |
| **Construction subtotal** | | | | **$ 550,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 550,000 | $ 55,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 550,000 | $ 27,500 |
| Reporting. | 1 | lump sum | $ 10,000 | $ 10,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 642,500** |
| **Annual Operating, Maintenance and Monitoring, Years 3 - 30** | 28 | year | $ 0 | $ 0 |
| **Project Total, Net Present Value, 2020** | | | | **$ 642,500** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 5**
**Cost Estimate for Remedial Alternatives: Sandstone Hil**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Decommission Tank #5 and Tank #6. Sandstone Hill: 9.5 acres of Terraced Vegetated Cover; 3.1 acres of Constructed Wetlands, estimated 500 cubic yards of Ex-Situ Soil generated by terracing; use nitrogen impacted Groundwater to maintain optimum moisture content for soil composting. Projected timeframe for terraced maintenance cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Decommission/Salvage Tank #5 and Tank #6 | 1 | lump sum | $ 200,000 | $ 200,000 |
| Constructed wetlands (3.1 acres) | 3 | acres | $ 25,000 | $ 77,500 |
| Terraced vegetated cover using onsite soil, 9.5 acres | 10 | acres | $ 20,000 | $ 190,000 |
| Shredding 5,000 cubic yards of tree and yard debris | 5,000 | cubic yards | $ 10 | $ 50,000 |
| Hauling groundwater onsite, duration 6 months; trial and error, 50% by weight is resommended starting point; more will be added througout the process as pile dries and moisture is consumed by the process | 300,000 | gallons | $0.25 | $ 75,000 |
| Composting, 5,000 cubic yards of excavated soil, turn, weekly, duration 6 months | 5,000 | cubic yards | $ 40 | $ 200,000 |
| **Construction subtotal** | | | | **$ 792,500** |
| Bench/Pilot testing | 1 | lump sum | $ 20,000 | $ 20,000 |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 792,500 | $ 79,250 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 792,500 | $ 39,625 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 792,500 | $ 79,250 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 1,010,625** |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 4 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 5 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 6 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 7 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 8 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 9 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 10 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 11 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 12 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 13 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 14 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 15 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 16 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 17 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - cap inspections and maintenance, mowing, reporting. Year 18 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 19 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 20 | 1 | year | $ 15,000 | |

**Table 5**
**Cost Estimate for Remedial Alternatives: Sandstone Hil**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Decommission Tank #5 and Tank #6. Sandstone Hill: 9.5 acres of Terraced Vegetated Cover; 3.1 acres of Constructed Wetlands, estimated 500 cubic yards of Ex-Situ Soil generated by terracing; use nitrogen impacted Groundwater to maintain optimum moisture content for soil composting. Projected timeframe for terraced maintenance cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 21 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 22 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 23 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 24 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - inspections and maintenance, mowing, reporting. Year 25 | 1 | year | $ 15,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 26 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 27 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 28 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 29 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 55,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 180,928 |
| **Project Total, Net Present Value, 2020** | | | | **$ 1,191,553** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 6**
**Cost Estimate for Remedial Alternatives: Central Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Central Ponds: Terraced Constructed Wetlands of approximately 5 acres; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for maintenance and monitoring cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Constructed wetlands (5 acres); additional consideratioon for overexcavating into consolidated underlying sandstone. | 5 | acres | $ 50,000 | $ 250,000 |
| Shredding 5,000 cubic yards of tree and yard debris | 5,000 | cubic yards | $ 10 | $ 50,000 |
| Hauling groundwater onsite, duration 6 months; trial and error, 50% by weight is resommended starting point; more will be added througout the process as pile dries and moisture is consumed by the process. | 300,000 | gallons | $0.25 | $ 75,000 |
| Composting, 5,000 cubic yards of excavated soil, turn, weekly, duration 6 months. | 5,000 | cubic yards | $ 40 | $ 200,000 |
| **Construction subtotal** | | | | **$ 575,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 575,000 | $ 57,500 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 575,000 | $ 28,750 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 661,250** |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 4 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 5 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 6 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 7 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 8 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 9 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 10 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 11 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 12 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 13 | 1 | year | $ 15,000 | |

**Table 6**
**Cost Estimate for Remedial Alternatives: Central Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Central Ponds: Terraced Constructed Wetlands of approximately 5 acres; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for maintenance and monitoring cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 14 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 15 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 16 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 17 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 18 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 19 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 20 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 21 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 22 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 23 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 24 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 25 | 1 | year | $ 15,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 26 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 27 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 28 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 29 | 1 | year | $ 5,000 | |

**Table 6**
**Cost Estimate for Remedial Alternatives: Central Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Central Ponds: Terraced Constructed Wetlands of approximately 5 acres; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for maintenance and monitoring cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 105,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 188,448 |
| **Project Total, Net Present Value, 2020** | | | | **$ 849,698** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 7**
**Cost Estimate for Remedial Alternatives: Plant A**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Decommission Tank #5 and Tank #6 and remove concrete/rebar debris pile. Impermeable Cap, existing, 5 acres, Ex-situ Soil Composting, 1,000 cubic yards. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
<u>This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.</u>

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Remove concrete/rebar debris pile | 1 | lump sum | $ 200,000 | $ 200,000 |
| Supplementa and repairs to existing impermeable cap and add controls for runoff of nitrogen-impacted storm water | 15 | acres | $ 20,000 | $ 300,000 |
| Shredding 200 cubic yards of tree and yard debris | 200 | cubic yards | $ 10 | $ 2,000 |
| Hauling groundwater onsite, duration 6 months | 40,000 | gallons | $ 2 | $ 80,000 |
| Composting on-site, 1,000 cubic yards of excavated soil, turn, weekly, duration 6 months | 200 | cubic yards | $ 40 | $ 8,000 |
| **Construction subtotal** | | | | **$ 590,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 590,000 | $ 59,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 8,000 | $ 400 |
| Contingency, ~ 10% of construction | 10% | lump sum | $ 590,000 | $ 59,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 708,400** |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |

**Table 7**
**Cost Estimate for Remedial Alternatives: Plant A**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Decommission Tank #5 and Tank #6 and remove concrete/rebar debris pile. Impermeable Cap, existing, 5 acres, Ex-situ Soil Composting, 1,000 cubic yards. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years. This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 26 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 27 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 28 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 29 | 1 | year | $ 5,000 | |

**Table 7**
**Cost Estimate for Remedial Alternatives: Plant A**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Decommission Tank #5 and Tank #6 and remove concrete/rebar debris pile. Impermeable Cap, existing, 5 acres, Ex-situ Soil Composting, 1,000 cubic yards. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 50,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 236,536 |
| **Project Total, Net Present Value, 2020** | | | | **$ 944,936** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

Table 8
Cost Estimate for Remedial Alternatives: Western Ponds
Former Farmland Nitrogen Plant
Lawrence, Kansas



**Remedy Description:** Constructed wetlands 3.1 acres; composting; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
<u>This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.</u>

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Constructed wetlands (3.1 acres) | 3 | acres | $ 25,000 | $ 77,500 |
| Vegetated restoration of all disturbed areas | 1 | acres | $ 5,000 | $ 5,000 |
| Shredding 200 cubic yards of tree and yard debris | 200 | cubic yards | $ 10 | $ 2,000 |
| Hauling groundwater onsite for composting, duration 6 months; trial and error, 50% by weight is recommended starting point; more will be added througout the process as pile dries and moisture is consumed by the process | 40,000 | gallons | $2.00 | $ 80,000 |
| Composting, 200 cubic yards of excavated soil, turn, weekly, duration 6 months | 200 | cubic yards | $ 40 | $ 8,000 |
| **Construction subtotal** | | | | **$ 172,500** |
| Bench testing | 1 | lump sum | $ 20,000 | $ 20,000 |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 172,500 | $ 17,250 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 8,000 | $ 400 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 172,500 | $ 17,250 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 227,400** |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |

**Table 8**
**Cost Estimate for Remedial Alternatives: Western Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Constructed wetlands 3.1 acres; composting; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
<u>This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.</u>

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 20,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 26 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 27 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 28 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 29 | 1 | year | $ 5,000 | |

**Table 8**
**Cost Estimate for Remedial Alternatives: Western Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Constructed wetlands 3.1 acres; composting; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
<u>This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.</u>

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - well abandonments; reporting. Year 30 | 1 | year | $ 50,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 236,536 |
| **Project Total, Net Present Value, 2020** | | | | **$ 463,936** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 9a**
**Cost Estimate for Remedial Alternatives: Eastern Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Eastern Ponds: 23.1 acres of constructed wetlands. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Constructed wetlands (23.1 acres) | 23 | acres | $ 25,000 | $ 577,500 |
| **Construction subtotal** | | | | **$ 577,500** |
| Bench testing | 1 | lump sum | $ 25,000 | $ 25,000 |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 577,500 | $ 57,750 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 577,500 | $ 28,875 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 577,500 | $ 57,750 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 746,875** |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 4 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 5 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 6 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 7 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 8 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 9 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 10 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 11 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 12 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 13 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 14 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 15 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 16 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 17 | 1 | year | $ 15,000 | |

**Table 9a**
**Cost Estimate for Remedial Alternatives: Eastern Ponds**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 18 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 19 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 20 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 21 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 22 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 23 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 24 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 25 | 1 | year | $ 15,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 105,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 188,448 |
| **Project Total, Net Present Value, 2020** | | | | **$ 935,323** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 9b**
**Cost Estimate for Remedial Alternatives: Eastern Ponds as Constructed Wetlands and Landfill**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Eastern Ponds: 23.1 acres of constructed wetlands. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Constructed wetlands (18 acres) | 18 | acres | $ 25,000 | $ 450,000 |
| Landfill, vegetated cover, monitoring wells (x4) | 5 | acres | $ 20,000 | $ 102,000 |
| **Construction subtotal** | | | | **$ 552,000** |
| Bench testing | 1 | lump sum | $ 25,000 | $ 25,000 |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 552,000 | $ 55,200 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 552,000 | $ 27,600 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 552,000 | $ 55,200 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 715,000** |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |

**Table 9b**
**Cost Estimate for Remedial Alternatives: Eastern Ponds as Constructed Wetlands and Landfill**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance, mowing, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 25,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 105,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 301,170 |
| **Project Total, Net Present Value, 2020** | | | | **$ 1,016,170** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 10**
**Cost Estimate for Remedial Alternatives: Bag Warehouse**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Impermeable Cap 3.6 acres total - existing as of October 2019, Soil Composting. Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.
This scenario is not anticipated to achieve final regulatory closure criteria within the 30 year projected timeframe.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Impermeable cap exists, minor repairs where disturbed soil is removed | 3.6 | acres | $ 2,500 | $ 9,000 |
| Shredding 200 cubic yards of tree and yard debris | 200 | cubic yards | $ 10 | $ 2,000 |
| Hauling groundwater onsite, duration 6 months | 40,000 | gallons | $ 2 | $ 80,000 |
| Composting, 200 cubic yards of excavated soil, turn, weekly, duration 6 months | 200 | cubic yards | $ 40 | $ 8,000 |
| **Construction subtotal** | | | | **$ 99,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 99,000 | $ 9,900 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 99,000 | $ 4,950 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 99,000 | $ 9,900 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 123,750** |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |

**Table 10**
**Cost Estimate for Remedial Alternatives: Bag Warehouse**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Monitoring and Maintenance - Groundwater and surface water monitoring, inspections and maintenance; reporting. Year 3 | 1 | year | $ 15,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 2 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 50,000 | |
| **Annual Operating, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 180,176 |
| **Project Total, Net Present Value, 2020** | | | | **$ 303,926** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 11a**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater - Discharge to Surface Water Without Treatment**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Groundwater and Storm (surface) water: Hydraulic control, 23.1 acres of wetlands. Long Term Monitoring. Assumes four recovery wells, (three are new) to recover groundwater near PSW-5B2 and PW-9 (pumping at ~200 gpm, combined) additional capacity of 100 from surface water = total of 300 gpm capacity; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Install three additional pumping wells (drilling and pump installation) for hydraulic control of off-site migration | 3 | each | $ 50,000 | $ 150,000 |
| **Construction subtotal** | | | | **$ 150,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 150,000 | $ 15,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 150,000 | $ 7,500 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 150,000 | $ 15,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 187,500** |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Electric plus Quarterly groundwater monitoring and reporting year 3 | 1 | year | $ 40,000 | |
| Post-closure monitoring and reporting year 26, pumps off | 1 | year | $ 10,000 | |

**Table 11a**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater - Discharge to Surface Water Without Treatment**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Post-closure monitoring and reporting years 27, pumps off | 1 | year | $ 10,000 | |
| Post-closure monitoring and reporting years 28, pumps off | 1 | year | $ 10,000 | |
| Post-closure monitoring and reporting years 29, pumps off | 1 | year | $ 10,000 | |
| Post-closure monitoring and reporting; Decommissioning - abandonment of wells; reporting. year 30 | 1 | year | $ 100,000 | |
| **Annual Operating, Electric, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 473,073 |
| **Project Total, Net Present Value, 2020** | | | | **$ 660,573** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 11b**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater with Treatment by Constructed Wetlands and Discharge to Surface Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Groundwater and Storm (surface) water: Hydraulic control, 23.1 acres of wetlands. Long Term Monitoring. Assumes four recovery wells, (three are new) to recover groundwater near PSW-5B2 and PW-9 (pumping at ~200 gpm, combined) additional capacity of 100 from surface water = total of 300 gpm capacity; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Install three additional pumping wells (drilling and pump installation) for hydraulic control of off-site migration | 3 | each | $ 50,000 | $ 150,000 |
| **Construction subtotal** | | | | **$ 150,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 150,000 | $ 15,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 150,000 | $ 7,500 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 150,000 | $ 15,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 187,500** |
| Electric, Groundwater monitoring, wetlands inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |

**Table 11b**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater with Treatment by Constructed Wetlands and Discharge to Surface Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Electric, Groundwater monitoring, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 75,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 26 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 27 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 28 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Year 29 | 1 | year | $ 5,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 100,000 | |
| **Annual Operating, Electric, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 864,027 |
| **Project Total, Net Present Value, 2020** | | | | **$ 1,051,527** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 11c**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater with On-site Industrial Pre-Treatment Discharge to Surface Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Groundwater and Storm (surface) water: Hydraulic control, 23.1 acres of wetlands. Long Term Monitoring. Assumes four recovery wells, (three are new) to recover groundwater near PSW-5B2 and PW-9 (pumping at ~200 gpm, combined) additional capacity of 100 from surface water = total of 300 gpm capacity; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Install three additional pumping wells (drilling and pump installation) for hydraulic control of off-site migration | 3 | each | $ 50,000 | $ 150,000 |
| Bench and Pilot testing | 1 | lump sum | $ 200,000 | $ 200,000 |
| Install pre-packaged two-stage ammonia and nitrate removal pre-treatment system. | 1 | lump sum | $ 4,000,000 | $ 4,000,000 |
| **Construction subtotal** | | | | **$ 4,350,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 4,350,000 | $ 435,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 4,350,000 | $ 217,500 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 4,350,000 | $ 435,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 5,437,500** |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |

**Table 11c**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater with On-site Industrial Pre-Treatment Discharge to Surface Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | |
|---|---|---|---|
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 |

**Table 11c**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater with On-site Industrial Pre-Treatment Discharge to Surface Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Electric, Groundwater monitoring, treatment system Operations, maintenance and monitoring, waste byproducts disposal, inspections and maintenance, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 300,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Year 26 | 1 | year | $ 50,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Year 26 | 1 | year | $ 50,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Year 26 | 1 | year | $ 50,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Year 26 | 1 | year | $ 50,000 | |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Decommissioning - abandonment of wells; reporting. Year 30 | 1 | year | $ 150,000 | |
| **Annual Operating, Electric, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 3,439,943 |
| **Project Total, Net Present Value, 2020** | | | | **$ 8,877,443** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

Unknowns for soil remediation include, but are not limited to: an updated estimate of the total volume, mass and range of nitrogen concentrations present in surface (<2 feet below ground surface) and subsurface (> 2 feet bgs) soil which may require remediation. Unknown quantities for groundwater remediation include, but are not limited to: total volume, mass and range of nitrogen compounds in alluvial, perched, and sandstone aquifers; interactions between all three aquifers in the vicinity of the Bag Warehouse, Sandstone Hill, West Extension Pond, Regional Detention Basin, PSW-5B2, and PW-9.

Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

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Power consumption, sewerage, and any other future utility requirements and rates are unknown. Once power requirements are known, supplemental or substitute sources of energy such as wind and solar may be more economical.

**Table 11d**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater and Storm Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

**Remedy Description:** Groundwater and Storm (surface) water: Hydraulic control, 23.1 acres of wetlands. Long Term Monitoring. Assumes four recovery wells, (three are new) to recover groundwater near PSW-5B2 and PW-9 (pumping at ~200 gpm, combined) additional capacity of 100 from surface water = total of 300 gpm capacity; Perform five-year reviews and annual groundwater sampling in perpetuity. Projected timeframe for cost estimating purposes is 30 years.

| Item | Quantity | Unit | Unit Cost | Cost |
|---|---|---|---|---|
| Install three additional pumping wells (drilling and pump installation) for hydraulic control of off-site migration | 3 | each | $ 50,000 | $ 150,000 |
| Install connection to lift station, 1,000 feet of 8-inch HDPE piping, fittings and controls | 1 | lump sum | $ 250,000 | $ 250,000 |
| Upgrade Lift Station | 1 | lump sum | $ 250,000 | $ 250,000 |
| **Construction subtotal** | | | | **$ 650,000** |
| Design and permitting, ~10% of construction costs | 10% | lump sum | $ 650,000 | $ 65,000 |
| Project administration and management, ~5% of construction costs | 5% | lump sum | $ 650,000 | $ 32,500 |
| Contingency, ~10% of construction costs | 10% | lump sum | $ 650,000 | $ 65,000 |
| **Total Capital (Design and Construction) Cost (in 2020 dollars)** | | | | **$ 812,500** |
| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 | |
| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 | |
| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 | |
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**Table 11d**
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**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | |
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| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 |
| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 |
| Electric, Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 3 | 1 | year | $ 100,000 |
| Groundwater monitoring, recovery well inspections and maintenance; reporting. Year 26 pumps off | 1 | year | $ 10,000 |
| Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 26 pumps off | 1 | year | $ 10,000 |
| Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 26 pumps off | 1 | year | $ 10,000 |
| Groundwater and sewer permit monitoring, recovery well inspections and maintenance; reporting. Year 26 pumps off | 1 | year | $ 10,000 |
| Post-Closure Monitoring - Annual monitoring of groundwater and surface water; reporting; minimal preventative maintenance of mothballed treatment system. Decommissioning - disconnect and block discharge piping, remove controls, abandonment of wells; reporting. Year 30 | 1 | year | $ 100,000 |

**Table 11d**
**Cost Estimate for Remedial Alternatives: Site-Wide Groundwater and Storm Water**
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| | | | | |
|---|---|---|---|---|
| **Annual Operating, Electric, Maintenance and Monitoring, Net Present Value, 2020 - Years 3 - 30** | | | | $ 1,149,404 |
| **Project Total, Net Present Value, 2020** | | | | **$ 1,961,904** |

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

At the City of Lawrence's request, these draft and preliminary costs have been estimated without benefit of an updated conceptual site model based on completing the Data Gap Study (DGS), thorough evaluation of Remediation Alternatives arising from the DGS, conditions arising from negotiating a new Consent Order, Corrective Action Decision, or environmental permits necessitated by the final selected remedy or remedies.

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Unknown volume, total mass or nitrogen contamination, accurate estimate of average nitrogen concentrations in groundwater, and groundwater withdrawal rate for alluvial aquifer wells necessary to hydraulically prevent groundwater containing greater than 10 mg/L nitrate and 2 mg/L ammonia in groundwater from migrating beyond the current Site boundaries.

During the alternative remediation evaluation, additional technologies may be selected and approved by the KDHE (overseeing regulatory agency). These estimates should not be considered accurate for budgeting purposes, but merely intended to provide an overall gross estimate. These scenarios are subject to change as further data are collected.

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**Table 12**
**Remedial Alternatives Comparisons***
**Former Farmland Nitrogen Plant**
**Lawrence, Kansas**

| Alternative | Cost | Compliance with Remedial Action Objectives | Long-Term Effectiveness | Implementability | Average Rating |
|---|---|---|---|---|---|
| **No Action** | **$652,000** | **0** | **0** | **10** | **3** |
| **Soil** | | | | | |
| Sandstone Hill | $1,191,553 | 9 | 8 | 9 | 9 |
| Central Ponds | $849,698 | 8 | 8 | 7 | 8 |
| Plant A | $944,936 | 9 | 9 | 9 | 9 |
| Western Ponds | $463,936 | 9 | 9 | 7 | 8 |
| Eastern Ponds - Constructed Wetlands | $935,323 | 9 | 9 | 9 | 9 |
| Eastern Ponds - Constructed Wetlands, Onsite Landfill, East Lime Pond | $1,016,170 | 9 | 9 | 6 | 8 |
| Bag Warehouse | $303,926 | 9 | 9 | 9 | 9 |
| **Site-Wide Groundwater** | | | | | |
| Hydraulic Containment - Discharge to Surface Water without Treatment | $660,573 | 5 | 9 | 9 | 8 |
| Hydraulic Containment - Onsite Constructed wetlands treatment | $1,051,527 | 9 | 9 | 5 | 8 |
| Hydraulic Containment - Onsite Industrial Pre-treatment | $8,877,443 | 9 | 9 | 4 | 7 |
| Hydraulic Containment - Discharge to Sanitary Sewer without Treatment | $1,961,904 | 9 | 9 | 0 | 6 |

* Qualitative scoring, 0 being worst or least favorable, 10 being best, or most favorable

Assumptions:

Costs have been estimated in 2019 dollars based on GHD's experience with similar sites in similar settings.

As applicable, bench and pilot testing has been estimated to precede full scale design and implementation, based on our experience. Construction and salvage costs have been estimated based on our experience without soliciting competitive bids from multiple qualified contractors using detailed construction or performance plans & specifications.

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# Appendices

# Appendix A
# Corrective Action Decision – March 15, 2010

KANSAS
DEPARTMENT OF HEALTH
AND ENVIRONMENT
Division of Environment

*Mark Parkinson, Governor*
*Roderick L. Bremby, Secretary*

www.kdheks.gov

March 15, 2010

Kamyar N. Manesh, P.E.
Trust Administrator
SELS Administrative Services, LLC
11206 Thompson Avenue
Lenexa, KS 66219

**RE: Final Corrective Action Decision (CAD)**
**Former Farmland Nitrogen Plant, Lawrence, Kansas**

Dear Mr. Manesh:

The Kansas Department of Health and Environment (KDHE) has finalized the Corrective Action Decision (CAD) for the Former Farmland Industries Nitrogen Plant, Lawrence, Kansas. A "Declaration of Corrective Action Decision" was signed by Secretary Bremby on March 3, 2010. The Final CAD identifies the remedy selected to address contamination at the Site. A copy of the Final CAD is enclosed for your records.

If you have any questions, please call me at (785) 296-1935 or contact me by e-mail at pgreen@kdheks.gov.

Sincerely,

Pamela D. Green

Pamela D. Green
Environmental Scientist
Restoration and Long-Term Stewardship Unit
Bureau of Environmental Remediation

Attachment

Cc: Rick Bean > Deanna Ross > File: C4-023-00009 1.0
Gary Blackburn (without attachment)
Kurt Limesand, EPA Region VII

## KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
## FINAL CORRECTIVE ACTION DECISION
## FORMER FARMLAND INDUSTRIES NITROGEN PLANT SITE
## LAWRENCE, KANSAS

## DECLARATION OF CORRECTIVE ACTION DECISION

### SITE NAME AND LOCATION

**Former Farmland Industries Nitrogen Plant Site**
**Lawrence, Douglas County, Kansas**

### STATEMENT OF BASIS AND PURPOSE

**The Final Corrective Action Decision document presents the corrective action selected by the Kansas Department of Health and Environment (KDHE) for the Former Farmland Industries Nitrogen Plant Site located in Lawrence, Kansas. The Comprehensive Investigation (CI) at the site determined that nitrate and ammonia are present at elevated concentrations in groundwater, soil, sediments, and surface and storm water at the Site, exceeding the federal drinking water standard and corresponding KDHE Tier 2 risk-based screening levels in a non-residential setting for soil.**

**The Remedial Action Plan (RAP) evaluated various remedial action alternatives to address contamination at the site. The remedial actions selected for the site were developed on the basis of documents and information contained in the Administrative Record File.**

### DESCRIPTION OF THE SELECTED REMEDIAL ACTIONS

**KDHE has determined that the selected corrective action, as described and evaluated in the Final Corrective Action Decision, meets the criteria established for selection and will be protective of human health and the environment. The remedial actions selected for the Former Farmland Industries Nitrogen Plant Site include the following elements:**

- **Continued operation of the groundwater containment system;**
- **Addition of a new groundwater recovery well as a supplement to the existing groundwater containment system;**
- **Construction of a groundwater interceptor trench near the Central Ponds area;**
- **Installation of a sump to capture fertilizer-contaminated water in the Dam Pond for land application;**
- **Ongoing monitoring of groundwater on- and off-site to ensure the effectiveness of the combined groundwater containment systems;**
- **Reclamation of fertilizer-contaminated groundwater and surface water through land application;**
- **Ongoing maintenance of current surface cover in certain areas of the Site to protect surface water and groundwater quality;**

- **Ongoing compliance with the Post-Closure Care requirements for the closed Chrome Reduction System unit;**
- **Desludging of the East and West Effluent Ponds to allow the eventual reconfiguration of clean storm water drainage through the Site until storm water can be routed through the Site without becoming contaminated;**
- **Ongoing monitoring of surface water quality for the National Pollutant Discharge Elimination System permit and the Storm Water Management Plan;**
- **Limited excavation of fertilizer-contaminated soil on the Sandstone Hill and in the Central Ponds area;**
- **Excavation of fertilizer-contaminated sediments from the West Extension, West Effluent, East Effluent, and Dam Ponds, and consolidation and capping of those sediments in the West Lime, Rundown, and East Lime Ponds;**
- **Contingency removal of fertilizer-contaminated soil areas in the Northeast Production Area and the #2 Urea Plant area to facilitate Site redevelopment;**
- **Clean-out of the Imhoff tank, flushing of the sewer/pump station, and plugging of sewer lines;**
- **Contingency plugging of facility production wells if not re-used; and,**
- **Application of various land use restrictions across the Site to prevent exposures and ensure proper management of contaminated water, sediments, and soil.**

## DECLARATION

**The selected remedial actions are protective of human health and the environment; attain state, federal and local requirements that are applicable or relevant and appropriate to this corrective action; and, provide cost-effective performance. The remedial actions will reduce contaminant mobility at the Former Farmland Industries Nitrogen Plant Site. In selecting and declaring this corrective action, KDHE believes implementation of the remedial actions will have a beneficial effect on heath and the environment.**

3/3/2010

**Roderick L. Bremby**
**Secretary**

**Date**

**Attachment: Final Corrective Action Decision**

Curtis State Office Building
1000 SW Jackson, Suite 410
Topeka, Kansas 66612-1367

**Kansas Department of Health and Environment**

# Final
# Corrective Action Decision

## FORMER FARMLAND INDUSTRIES NITROGEN PLANT SITE
## 1608 North 1400 Road
## Lawrence, Kansas

**February 2010**

**Bureau of Environmental Remediation**

# TABLE OF CONTENTS

**FIGURES**

# LIST OF ACRONYMNS

| | |
|---|---|
| ACM | Asbestos-Containing Materials |
| AR | Administrative Record |
| AST | Aboveground Storage Tank |
| BGS | Below Ground Surface |
| CAD | Corrective Action Decision |
| CAP | Corrective Action Plan |
| CAS | Corrective Action Study |
| CI | Comprehensive Investigation |
| COC | Contaminant of Concern |
| CRS | Chrome Reduction System |
| DRO | Diesel Range Organics |
| EPA | United States Environmental Protection Agency |
| GRO | Gasoline Range Organics |
| IRIS | Integrated Risk Information System |
| KDHE | Kansas Department of Health and Environment |
| LUR | Land Use Restriction |
| MCL | Maximum Contaminant Level |
| mg/kg | milligram per kilogram |
| mg/L | milligram per Liter |
| MSL | Mean Sea Level |
| NPDES | National Pollutant Discharge Elimination System |
| PCB | Polychlorinated Biphenyls |
| PRG | Preliminary Remediation Goals |
| RAP | Remedial Action Plan |
| RCRA | Resource Conservation and Recovery Act |
| RFA | RCRA Facility Assessment |
| RSK | Risk-Based Standard for Kansas |
| SMP | Storm Water Management Plan |
| TKN | Total Kjeldahl Nitrogen |
| TPH | Total Petroleum Hydrocarbons |
| UAN | Urea Ammonium Nitrate |
| VOC | Volatile Organic Compound |

# 1.0 PURPOSE OF CORRECTIVE ACTION DECISION

The primary purposes of the final CAD are to: 1) summarize information from the key site documents including the Site Characterization Report dated February 1, 2006, and the Remedial Action Plan Report (RAP) dated May 22, 2009; 2) briefly describe the alternatives for site remediation detailed in the RAP; 3) identify and describe the Kansas Department of Health and Environment's (KDHE's) selected remedy for the soil and groundwater contamination at the Main and Avenue G Site (the Site); and, 4) document comments and KDHE's responses to the public comments received regarding the draft CAD. The public was encouraged to review and comment on the preferred remedy presented in the draft CAD during the public comment period held from October 26 to November 25, 2009.

KDHE has selected a final remedy for the Site after reviewing and considering all information submitted during the 30-day public comment period. Shaw Environmental, Inc., the consultant for the Former Farmland Industries Nitrogen Plant, prepared key documents for the Site, including the RAP. Work performed during the Site Characterization and RAP process followed the terms outlined in a Consent Agreement between Farmland Industries and KDHE. The public was encouraged to review and comment on the technical information presented in the Site Characterization Report, RAP, and other documents contained in the Administrative Record file (AR file). The AR file includes all pertinent documents and site information which form the basis and rationale for selection of the remedial alternative. The Administrative Record file has been made available and continues to be available for public review and copying during normal business hours at the following location:

Kansas Department of Health and Environment
Bureau of Environmental Remediation
1000 SW Jackson, Suite 410
Topeka, Kansas 66612-1367
CONTACT: Pamela Green, Environmental Scientist
Telephone Number: (785) 296-1935
E-mail: pgreen@kdheks.gov

For convenience to interested members of the public, copies of the RAP report and the draft CAD have been made available for review and copying during normal business hours at the following location:

Lawrence Public Library
707 Vermont Street
Lawrence, Kansas 66044
(785) 843-3833

# 2.0 SITE BACKGROUND

## *2.1 Site Location*

The Former Farmland Industries Nitrogen Plant Site (Site) is located at 1608 North 1400 Road in Lawrence, Kansas in Douglas County as shown in Figure 1. The Site extends into Sections 4 and 5 of Township 13 South, Range 20 East. Covering an area of 467 acres in size, the Site extends approximately 1.9 miles from north to south and varies in width from 0.7 to 1.1 miles from west to east. The approximate boundaries of the Site are illustrated in Figure 1. The Site is bounded on the north by 15th Street and the Burlington Northern Santa Fe Railroad. The remaining Site property lines border undeveloped and developed industrial property on the east, mixed commercial and residential areas on the west, and State Highway K-10 on the south. The land use within the Site is zoned for commercial and industrial use.

## *2.2 Physical Setting*

The Site lies near the boundary of the Dissected Till Plain and the Osage Plain sections of the Central Lowlands physiographic province. The major topographic features near the Site are the east-trending Kansas River Valley and a series of north-south oriented upland cuestas formed by differential erosion of the bedrock. Surface water drainage from the plant is toward the Kansas River. Relief at the Site is dominated by a sandstone bluff overlooking the Kansas River Valley. The average elevation of the Kansas River Valley is approximately 817 feet above mean sea level (MSL), while the top of the bluff within the Site rises to just over 900 feet above MSL.

Bedrock occurs in outcrops and varies at depths of up to 56 feet below ground surface (bgs) near the northern edge of the Site. Outcropping bedrock at the Site consists of the Pennsylvanian-Age Stranger Formation of the Douglas Group. Deeper bedrock layers encountered in wells and borings at the Site include the Weston Shale and members of the Stanton Limestone.

Three general water-bearing layers have been identified on the Site:

1) <u>Silty clay and overburden unit</u> – This unit consists primarily of silty clays and clays (including fill and native soil). The silty clay unit refers to shallow saturated soils in the area of the process ponds and north into the Kansas River floodplain. The overburden unit refers to discontinuous areas of saturated sediments overlying bedrock at some locations on the Site. The silty clay and overburden units are believed to be unconfined.

2) <u>Deep alluvial aquifer (Kansas River alluvium)</u> – This unit consists of sandy clays, sands, and gravel. The alluvial aquifer may be semi-confined where it is overlain by the silty clay unit but is otherwise unconfined. The alluvial aquifer (Kansas River alluvium) is present in the area north of the northeast ponds and along the north side of the Sandstone Hill. It increases in thickness northward into the Kansas River floodplain. Groundwater flow in the alluvial aquifer is generally toward the northeast.

3) <u>Bedrock unit</u> – This unit consists of sandstone, limestone, and shale. The bedrock unit may be either confined or unconfined depending on the overlying unconsolidated material. Clay and shale aquitard units are present within the water-bearing units and are

the source of surface seeps observed at the Site. The bedrock unit underlies the unconsolidated aquifers. Overburden thickness ranges from 0 feet in several locations to 56 feet at the north end of the Site. The uppermost rock unit appears to be the Vinland Shale member of the Stranger Formation, and wells have penetrated as deep as what is believed to be the Eudora Shale member of the Stanton Limestone.

### *2.3 SITE HISTORY*

The former Farmland Industries Nitrogen Manufacturing Plant in Lawrence, Kansas, began operations in 1954, producing a wide range of nitrogen-based fertilizers. The plant was expanded and updated during its history to provide a variety of fertilizer products, including anhydrous ammonia, nitric acid, granular urea, ammonium nitrate, and urea ammonium nitrate (UAN) solution. The production areas at the plant consisted of a wide variety of structures and buildings where diverse support and ancillary functions were operating, including but not limited to boilers, wastewater treatment, waste disposal units, and facility maintenance. All operations ceased at the facility in 2001 because of the economic downturn of the fertilizer market, rising energy costs, and the eventual bankruptcy of Farmland Industries in 2002.

In 2004 following approval of Farmland Industries' Plan of Reorganization by the Bankruptcy Court and concurrence from KDHE, the FI Kansas Remediation Trust (Trust) was formed and funded with approximately \$7.0 million (initial remediation fund) to address the remaining environmental impairments at the Site. In 2006 the Trust was funded with approximately \$7.8 million (initial administrative fund) to facilitate the sale and manage the administrative activities of the Site.

The Trust, through SELS Administrative Services, LLC as Trustee, manages the environmental and administrative functions of the Site. The Trust retained Shaw Environmental and Infrastructure, Inc. (Shaw), to help manage the mandated compliance and cleanup of the Site in close cooperation with and under the supervision of KDHE and the United States Environmental Protection Agency (EPA). KDHE is the primary beneficiary for the Trust.

The Site has undergone several episodes of environmental investigation since the 1970's. Early investigations focused on groundwater and soil impacts related to the ponds, located in the northern portion of the Site, and storm water runoff from process areas. Preliminary remedial actions in the form of groundwater interception trenches around the northern storm water and wastewater ponds were implemented in the late 1970's. In the 1980's, the Chrome Reduction System (CRS) surface impoundment at the Site was identified as a hazardous waste management unit subject to regulation under the Resource Conservation and Recovery Act (RCRA). This system was taken out of service, and contaminated soil was removed in 1987. This portion of the Site has been undergoing groundwater cleanup under a KDHE permit since that time.

A RCRA Facility Assessment (RFA) was completed in September 1990 and identified specific areas where waste had been managed and releases of contaminants to the environment may have occurred. Farmland and KDHE entered into a Consent Agreement (Consent Order Case No. 92-E-27) on January 27, 1993, to conduct a Comprehensive Investigation/Corrective Action Study (CI/CAS). This investigation was completed with the submittal of the CI report in January 1994 and a supplemental report in October 1994. In 1997 a Corrective Action Plan (CAP) was approved by KDHE with a request that Farmland Industries install a French Drain system and recovery wells in the northern part of the Site, including reusing/recycling contaminated groundwater in plant processes. The CAP was developed with the understanding that the facility was an operating facility and the goal was to prevent environmental contamination from migrating off the Site. After termination of plant operations in 2001, the recycle/reuse assumptions were no longer applicable, and KDHE requested that the Trust perform additional investigations and develop a modified remedy. Quarterly groundwater monitoring activities and Performance Evaluation Reports with summaries of the nitrate and ammonia recovery systems have been submitted to KDHE since 1998.

Following the bankruptcy of Farmland Industries and establishment of the FI Kansas Remediation Trust, an evaluation of the existing conditions was made and a strategy was developed for advancing the Site toward remediation and redevelopment since the property was no longer used for manufacture of fertilizer. A Strategy Document submitted to KDHE in November 2004 became the basis for future site characterization and remedial action work.

In 2005 a comprehensive Site Characterization was conducted in which environmental data was collected to identify the lateral and vertical extent of contaminants identified in the 1990 RFA report. Supplemental investigations were conducted in March 2006, August through October 2007, and October 2008.

Following the comprehensive Site Characterization and completion of several interim remedial measures, KDHE authorized the Trust to proceed with preparation of the RAP. The RAP includes a summary of investigations and remediation-related activity previously carried out at the Site, identifies environmental issues that require further action, evaluates remedial alternatives, identifies priorities, proposes remedial actions, and provides cost estimates to implement the proposed remedies.

The goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property and will prevent unacceptable human exposure to residual site contamination under that use scenario. The elements of the proposed remedy are listed in a prioritized manner assuming future use as an industrial/commercial property.

# 3.0 SUMMARY OF THE SITE CHARACTERIZATION

## *3.1 Site Characterization*

### 3.1.1 Site Characterization Activities

Shaw was retained by the Trust to perform a Site Characterization in 2005. The purpose of the site characterization activity was to collect sufficient data to determine the potential contribution of environmental impacts to surface water and groundwater quality, to evaluate potential human health impacts, and to identify the horizontal and vertical extent of the contamination at the property. A major focus of the site characterization was identification of surface and subsurface soil source areas that may be contributing to contamination to surface water and/or groundwater.

In support of the objectives, the Site was divided into six remedial management units based on former use and/or natural boundaries. These areas are as follows and as further described below:

- Area A: UAN Storage Area (Sandstone Hill)
- Area B: Northern Ponds
- Area C: Northwest Site Area
- Area D: Operations Area
- Area E: Southwest Site Area
- Area F: Southeast Site Area

The boundaries of the remedial management areas are shown in Figure 3.

The work plan for the Site Characterization effort was approved by KDHE in February 2005. The field activities conducted at the Site consisted of the following:

- Over 1,200 samples were collected from 404 sample locations;
- 838 soils, 184 sediment, and 68 groundwater samples were analyzed for nitrate plus nitrite and ammonia as nitrogen;
- 153 sediment samples were analyzed for Total Kjeldahl Nitrogen (TKN);
- 82 soils, 165 sediment, and 15 groundwater samples were analyzed for RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver);
- 54 sediment samples were analyzed for hexavalent chromium;
- 33 soil and 3 sediment samples were analyzed for Total Petroleum Hydrocarbons (TPH);
- 22 soil and 19 sediment samples were analyzed for Volatile Organic Compounds (VOCs); and
- 4 soil samples were analyzed for Polychlorinated Biphenyls (PCBs).

### 3.1.2 Site Characterization Results

Results of the Site Characterization investigation are discussed by area, and contaminants detected at concentrations above KDHE's site cleanup goals are identified for each area.

<u>Area A: UAN Storage Area (Sandstone Hill)</u>

Area A is comprised of what formerly had been designated as the UAN Storage and Concentrate Ponds Area (Sandstone Hill), Ammonium Nitrate Processing Area, Nitrate Bulk Warehouse, and included the UAN and the ammonium nitrate plants and associated support structures and buildings. This area comprises approximately 78 acres and lies in the topographically highest area in the north central portion of the Site and includes Sandstone Hill. Area A is divided into five sub-areas of interest:

1) UAN Aboveground Storage Tank (AST)/Former Concentrate Ponds Area – The UAN AST Area encompasses approximately 11.7 acres and consists of a six-million-gallon capacity AST (#6) and a two-million-capacity AST (#5) that were constructed in the area of the former concentrate ponds (UAN Lagoon Area). The former concentrate ponds were filled and graded in 1988. The ASTs are currently used to hold the water from the Rundown Pond, West Pond, and a portion of the groundwater from the interception trenches in the northwest area of the Site before being pumped out to agricultural fields located north of the Site. The majority of the total nitrogen in the surface soil in this area ranged from 100 milligrams per kilogram (mg/kg) to over 1,000 mg/kg, with concentrations increasing with depth. The highest concentrations were detected immediately west of AST #6 (formerly UAN storage tank) and ranged up to 6,750 mg/kg.

2) Central Ponds – The Central Ponds encompass approximately 0.5 acres along the southern boundary of Area A. The Central Ponds were designed to control surface water flow from the south side of Sandstone Hill during heavy rain events. The surface water overflowing from the Central Ponds was determined to contain high levels of nitrogen compounds and as such was previously directed to the East Effluent Pond located in Area B. Total nitrogen contamination of soil was limited to the footprint of the Central Ponds, where total nitrogen concentrations exceeded 10,000 mg/kg. Soil samples collected from outside the pond had total nitrogen concentrations that did not exceed 100 mg/kg. The data indicated that nitrogen contamination of soil was limited to the pond bottoms.

3) Northeast Production and Railcar Loading Area – The area includes the nitrate production area, service roads, and railroad spurs and covers approximately 8.6 acres. The majority of the surface soil contamination in this area has concentrations of total nitrogen ranging from 100 mg/kg to over 1,000 mg/kg. Concentrations to over 1,000 mg/kg increase with depth in the subsurface soil, with the maximum concentration of 3,973 mg/kg detected 21-23 feet bgs.

4) Southeast Production Area – The area covers approximately four acres. Total nitrogen in surface and shallow subsurface soils ranged from 100 mg/kg to 1,000 mg/kg. Concentrations increased greater than 1,000 mg/kg in the deeper subsurface soils, with one location as high as 23,130 mg/kg at a depth of six feet bgs.

5) Bag Warehouse Area – The area covers approximately two acres along the northern and eastern ends of the Bag Warehouse and includes the Dam Pond. Total nitrogen concentrations in surface soil were below 10 mg/kg, but increased in the subsurface with depth. Shallow subsurface soil samples (less than three feet bgs) ranged from 100

mg/kg to 1,000 mg/kg. Concentrations greater than 1,000 mg/kg were detected at 31 feet bgs.

Area B: Northern Ponds

Area B is comprised of a series of ponds located in the far northeastern area of the Site. These ponds, in order from west to east, are: Krehbiel Pond, West Pond, West Extension Pond, West Effluent Pond, East Effluent Pond, West Lime Pond, Rundown Pond, Overflow Pond, and East Lime Pond. This total area covers approximately 66 acres. These ponds were designed to receive different process waters and storm water runoff from the Site.

Nitrate and ammonia were detected in sediments accumulated in these ponds with concentrations of ammonia as high as 23,700 mg/kg and nitrate concentrations as high as 10,900 mg/kg. The majority of the nitrate and ammonia contamination in the northern ponds is found in these sediments and potentially the upper portion of the native clay bases immediately underlying the sediments. Arsenic was detected at concentrations up to 40.8 mg/kg. Chromium was detected at concentrations up to 3,400 mg/kg. Mercury was detected at concentrations up to 4.53 mg/kg.

Area C: Northwest Site Area

Area C is located in the northwestern portion of the Site and is comprised of approximately 77 acres of grass and wooded land. This area includes the Central Storm Water Pond Watershed. This area had not been used in the past for Site operations.

Nitrate plus nitrite concentrations detected in surface soils were as high as 12.7 mg/kg and ammonia concentrations as high as 57.8 mg/kg. The analytical results for the 34 soil samples analyzed for nitrogen compounds and the three soil samples analyzed for RCRA metals support that this area was not adversely impacted by plant operations.

Area D: Operations Area

Area D is located in the south central area of the Site and borders the north side of Highway K-10. This area covers approximately 56 acres and was the location of main plant operations. Area D is comprised of eleven sub-areas that have been designated as follows:

1) Oil Pond – The Oil Pond is located near the southeast corner of Area D and was used for fire control training with waste oil used as the ignitable medium. Insignificant concentrations of TPH as fuel product were detected in this area.

2) Spill Pond – The Spill Pond is located near the southeast corner of Area D and was constructed to contain potential spills from the unloading of #6 fuel oil. The highest concentration of TPH as fuel product (diesel range) was 4,500 mg/kg in surface soil.

3) Urea Area – The Urea Area includes the Urea Production Area, Urea Plant, and the Urea Bulk Warehouse. Urea was produced in this area, generating process waters high in concentrations of urea and ammonia. These process waters were formerly pumped to the Rundown Pond for re-use. Concentrations of ammonia in surface soils were found to be as high as 1,520 mg/kg near the central portion of the Urea Plant. The highest concentrations were generally found in the vicinity of the Urea Production

Area. Concentrations of total nitrogen in subsurface soils were found to be as high as 10,754 mg/kg near the central portion of the Urea Plant. Highest concentrations were generally found between the Urea Plant Production Area and the Urea Vault. Nitrate plus nitrite concentrations were detected as high as 299 milligrams per liter (mg/L). Ammonia was detected as high as 2,990 mg/L in the groundwater. Elevated nitrate plus ammonia concentrations cover an approximate combined area of 3.2 acres in Area D surface soils.

4) Chrome Reduction System – The CRS surface impoundment was operated from 1972 to 1984 to remove hexavalent chromium from water, which had been circulated through cooling towers to inhibit corrosion. The entire system consisted of an unlined ditch, the surface impoundment, a caustic pond, an acid water pond, and a sulfur dioxide storage building. Closure of the CRS surface impoundment was certified in early 1987 under a RCRA Closure Plan approved by KDHE. The CRS surface impoundment was not successfully decontaminated because chromium was detected at concentrations above acceptable limits in the groundwater beneath the Site. The scope of the RCRA Post-Closure Permit included corrective action and monitoring of the groundwater beneath the CRS for both chromium and pH. Since closure and corrective action were implemented, the chromium concentrations in groundwater in this area decreased to levels below the federal drinking water standard. However, samples from several monitoring wells and the drainage trench continue to have a pH below the acceptable range of 6 to 9. The 2008 Annual Report lists five of 15 monitoring locations having an average pH of less than 6.0, with the lowest being 3.87. The CRS continues to be subject to the Post-Closure Permit pending return of pH conditions in the groundwater to acceptable levels. Because this system has been characterized and managed under the guidance of the Bureau of Waste Management, this area was not included in the Site Characterization activities.

5) Paint Shop Maintenance Area – The former Paint Shop Area is located near the northeast corner of Area D and was used for the storage of paints, solvents, and used oil. Arsenic was detected in the surface soil at concentrations up to 22.1 mg/kg. Nitrate and ammonia were detected as high as 17.1 mg/kg and 105 mg/kg in the subsurface soil samples. Shallow groundwater was not encountered during the site investigation in the vicinity of the former Paint Shop Area.

6) Ammonia Production Area – The Ammonia Production Area is located near the south central portion of Area D and was used to produce ammonia. Concentrations of nitrate and ammonia in surface soil were found to be as high as 18.5 mg/kg and 213 mg/kg, respectively. Concentrations of nitrate and ammonia in subsurface soil were detected as high as 262 mg/kg and 1,560 mg/kg, respectively. Arsenic was detected at concentrations up to 31 mg/kg. Shallow groundwater was not encountered during the site investigation in the Ammonia Production Area.

7) Cooling Towers – The Area D Cooling Towers consist of 14 former cooling towers which had not yet been decommissioned and demolished down to the respective

concrete basins at the time of Site Characterization. See Section 3.2 for characterization results in this area.

8) Nitric Acid Area – Nitric acid was produced in this area for use during the production of ammonium nitrite. The area is located near the south central portion of Area D. Concentrations of nitrate and ammonia in the subsurface were detected as high as 806 mg/kg and 90.8 mg/kg, respectively. Nitrate and ammonia were also detected in four shallow groundwater samples at concentrations as high as 0.83 mg/L for ammonia and 21 mg/L for nitrate.

9) Boiler Furnace and Fuel Oil Storage – The Boiler Furnace and Fuel Oil Storage Area are located near the southern section of Area D. Fuel oil was burned in the boiler furnaces and was stored in aboveground tanks located just south of the furnaces. Shallow groundwater was not encountered during the site investigation in this area of the Site.

10) Old Ammonia Plant – The Old Ammonia Plant, used for ammonia production, is located near the southern section of Area D and consisted of large diesel compressors that contained oil, and used diesel as a fuel source. Concentrations of nitrate and ammonia in surface soil samples were found to be as high as 137 mg/kg and 15.0 mg/kg, respectively. Arsenic was detected in the surface soil at concentrations up to 25.5 mg/kg. Concentrations of nitrate and ammonia in subsurface soil samples were detected as high as 30.1 mg/kg and 204 mg/kg, respectively. Shallow groundwater was not encountered in the Old Ammonia Plant area.

11) Catalyst Landfill – The Catalyst Landfill was located in the northern portion of Area D and was constructed to receive spent catalysts produced in various operations. The landfill was operated between 1981 and 1989 on an as-needed basis with the approval of KDHE. Exploratory borings were advanced to identify the exact location of the former landfill. Once the boundaries were identified, four borings were advanced around the perimeter and two borings were advanced in the waste material. Catalyst material was encountered at approximately four feet bgs and extended to between 6.5 feet and 8.5 feet bgs. A sample of the buried catalyst material was retrieved at a depth of approximately four to eight feet and found to contain total chromium at a concentration of 10,100 mg/kg. This material was later removed and disposed off site as discussed below in Section 4.3.1.

<u>Area E: Southwest Site Area</u>

The Southwest Site Area consists of approximately 55 acres that border the western boundary of the Site and extend south of the administration building to Highway K-10. This area is vegetated with native grasses and has not been used for primary Site operations. Soil samples were collected from 13 locations; 36 were analyzed for nitrogen compounds and three for RCRA metals. The analytical results demonstrate that this area was not adversely impacted by former plant operations. Groundwater was not encountered in this area.

Area F: Southeastern Site Area

The Southeastern Site Area is approximately 90 acres of undeveloped natural terrain that contains primarily grasslands, shrubs and natural drainage features and was not used directly in production operations. This area is bordered to the south by Highway K-10 and to the east by an industrial park. Fifty-eight samples were collected from 29 soil boring and 14 sediment boring locations and analyzed for nitrate plus nitrite and ammonia. Maximum concentrations of nitrate plus nitrite and ammonia detected in surface soil samples were 6.2 mg/kg and 44.8 mg/kg, respectively. Of 26 subsurface soil samples collected, concentrations of nitrate plus nitrite and ammonia were detected up to 4.2 mg/kg and 448 mg/kg, respectively.

The majority of contamination was found in the northern half of the drainage ditch. Maximum concentrations of nitrate plus nitrite and ammonia detected in surface sediment were 514 mg/kg and 1,190 mg/kg, respectively. Maximum concentrations of nitrate plus nitrite and ammonia detected in subsurface sediment samples were 462 mg/kg and 1,750 mg/kg, respectively.

Arsenic was detected in Area F at concentrations up to 18.8 mg/kg.

Additional information regarding the results can be found in the *Site Characterization Report, Former Farmland Nitrogen Plant, Lawrence, Kansas,* dated February 1, 2006.

## *3.2 SUPPLEMENTAL INVESTIGATIONS*

A supplemental groundwater investigation was performed in March 2006 to assess the effectiveness of the interceptor trench/French drain system and recovery wells in preventing off-site migration of nitrate-impacted groundwater. The off-site groundwater area of interest extends from the northern property line of the former Farmland facility to the Kansas River. Fifteen groundwater samples were analyzed for ammonia-nitrogen and nitrate-nitrogen. The federal drinking water standard for nitrate and public drinking water supplies was exceeded in two locations. The results of this sampling in conjunction with many years of off-site monitoring conducted by Farmland and the Trust indicate that off-site groundwater concentrations are significantly lower than on-site concentrations and that the interceptor trench/French drain system and recovery wells are effective in containing nitrate-impacted groundwater and preventing further off-site migration. Additional information regarding the results can be found in the *Supplemental Groundwater Site Characterization Report,* dated May 9, 2006.

A supplemental soil investigation was performed within the footprints of the former cooling towers, ammonia plant, urea plant, nitric acid plant, and beneath the former urea storm water vault after demolition was complete. Within the cooling tower area, concentrations of metals and hexavalent chromium in soil samples were below levels of concern. In the Urea Plant Area, concentration of nitrate plus ammonia increased near the central portion and in the vicinity of the Urea Vault. Elevated levels of nitrate and ammonia are present in subsurface soil approximately 20 feet in depth, where concentrations were measured in excess of 5,000 mg/kg. Additional information regarding the results can be found in the *Supplemental Soil Investigation Report,* dated October 25, 2007.

In September 2008, a supplemental investigation was conducted by KDHE to further characterize several data gaps that were identified during review of the draft RAP. Four subsurface soil samples and 20 groundwater samples were analyzed for nitrate, ammonia, VOCs, or metals. Results confirmed the presence of an old landfill in the vicinity of the Old Ammonia Plant in Area D. Trash dump areas were identified by geophysical survey results and confirmed during the investigation. Additional information regarding the results can be found in the *KDHE Data Gap Investigation Report*, dated October 27, 2008.

# 4.0 SUMMARY OF INTERIM REMEDIAL MEASURES

Based on the numerous site characterization activities performed at the Site between 1974 and 2008, interim remedial measures were identified for several areas of the Site to address environmental issues of immediate concern. This section summarizes the interim remedial actions implemented at the Site.

## *4.1 AREA A*

### 4.1.1 Central Ponds

Interim remedial measures for the Central Ponds were implemented pursuant to the KDHE-approved Interim Measures Work Plan dated March 8, 2006. Over 1,300 cubic yards of nitrogen-impacted sediment were excavated to bedrock, approximately three feet deep, from the Central Ponds and placed in the East Lime Pond in Area B in May and June 2006. This material was removed to improve surface water runoff quality from this area. Approximately 2,700 cubic yards of backfill material, obtained on-site, was used to restore the surface grade in the Central Ponds area to eliminate future accumulation of surface water and the resulting deposition of sediments. Interim measures undertaken at the Central Ponds were documented in *Letter Report Interim Measures Activities* dated September 1, 2006.

Subsequent to the completion of the interim remedial measures of the Central Ponds, the area has been observed to be "wet" with some occasional standing water. The source of this water is believed to be shallow groundwater migrating southward from the Sandstone Hill area. The groundwater surfaces as surface seeps, and as the water evaporates, white crystalline material (ammonium nitrate) forms on the surface in the Central Pond area. The water quality of surface water which flows through this area is negatively impacted by this condition, particularly from early storm water runoff. As a result, backfill brought in during the interim remedial measure has been impacted by this highly contaminated water. The Central Pond Area remains a primary source area for nitrate and ammonia contamination of surface water runoff and is proposed for additional action in the RAP.

### 4.1.2 UAN AST/Former Concentrate Ponds Area

In November 2006 KDHE requested that drainage modifications be made to the area between AST 5 and AST 6 to eliminate standing water. The standing water resulted from surface water runoff that was retained because a berm prevented natural drainage. Samples collected from the standing water identified ammonia-nitrogen and nitrate-nitrogen at concentrations of 3 mg/L and 18 mg/L, respectively.

Interim remedial measures were implemented pursuant to the KDHE-approved Work Plan dated December 14, 2006, outlining the proposed activities to improve surface water drainage. On March 22-24, 2007, a 10-foot portion of the existing berm between AST 5 and AST 6 was excavated and removed. The area to the north of the berm was graded to direct surface water runoff toward the breach in the berm, ultimately entering the main storm water drainage ditch running south to north through the Site. Surface water drainage from the area between AST 5 and AST 6 is directed to the Overflow Pond along with other surface water runoff from Sandstone Hill in Area A. These activities were summarized in the document *Letter Report: Area A Drainage Modifications to Eliminate Standing Water between AST #5 and #6* dated May 1, 2007. At this time, no additional measures are proposed with respect to surface water drainage from this area.

## *4.2 AREA B*

### 4.2.1 East Lime Sludge Pond and West Lime Sludge Pond De-Watering

The East Lime Sludge Pond and the West Lime Sludge Pond were used to receive lime sludge generated during cold lime softening of water brought into the plant from off-site water supply wells. Over the years of operation, the West Lime Sludge Pond also received dredged materials from the East Effluent and West Effluent Ponds. A work plan was submitted to the KDHE on February 14, 2006, outlining the procedures and analytical work to be undertaken to dewater these ponds. Subsequently, KDHE requested further analytical data be collected while pumping the water and discharging it.

Water was transferred from the East Lime Sludge Pond and the West Lime Sludge Pond into the East Effluent Pond, where it was blended with storm water and discharged to the Kansas River under the existing National Pollutant Discharge Elimination System (NPDES) permit. An estimated 1.04 million gallons of water was removed from the two ponds to prepare for the consolidation of contaminated sediments in those ponds.

Since completion of the interim remedial measure, precipitation has collected in the low areas of these ponds. As a result, before further sediment placement or closure and capping, the water will need to be removed. The East Lime Sludge Pond and the West Lime Sludge Pond are proposed to be filled in and capped as landfills along with the Rundown Pond. If the East and West Effluent Ponds are removed from service, water in the East Lime Sludge Pond, West Lime Sludge Pond, and the Rundown Pond would need to be pumped to the Overflow Pond for use in land application.

### 4.2.2 Overflow Pond Sediment Removal

A work plan dated March 21, 2007, was submitted to KDHE proposing the decommissioning of six of the seven Area B ponds. The Overflow Pond was not to be decommissioned; rather, the sediment would be removed and the pond used to contain nitrogen-impacted storm water runoff and groundwater for future land application. At a May 16, 2007, meeting with KDHE, it was determined that the activities proposed for the Overflow Pond would be implemented but that the overall pond decommissioning activities would not be implemented at that time.

Field activities to complete the approved work on the Overflow Pond commenced on August 13, 2007, and were completed on September 24, 2007. A total volume of 15,154 cubic yards of accumulated sediments were removed to expose the native clay pond base of the Overflow Pond. The sediments were directly placed into the Rundown Pond along the entire length of the existing dike separating the Overflow Pond and the Rundown Pond and were track compacted with excavation equipment. The bottom of the Overflow Pond was shaped to provide a flat/gently sloping grade toward the southwest corner to facilitate future water removal for land application.

After confirmation sampling for nitrate and ammonia, modifications to the current storm water drainage system were performed to route potentially impacted storm water runoff from Area A to the Overflow Pond. When it is no longer necessary to contain this storm water for land application, the Overflow Pond can be taken out of service and decommissioned.

### 4.2.3 West Pond Sediment Removal and Piping Modifications

The West Pond is located north of the former Ammonium Nitrate Production Area and encompasses approximately 0.4 acres. Based on the results of the Site Characterization activities, sediment samples collected from the West Pond had measured concentrations of ammonia from 2,020 mg/kg to 18,000 mg/kg and total nitrogen concentrations of 3,350 mg/kg to 28,600 mg/kg. Groundwater near the West Pond was also found to contain elevated nitrogen levels.

Between May 14 and June 15, 2006, approximately 2,750 cubic yards of nitrogen-impacted sediment was excavated from the West Pond and placed in the East Lime Pond after dewatering. The West Pond was excavated down to bedrock, approximately three feet deep. Approximately 2,200 cubic yards of backfill material, obtained on-site, was used to restore the surface grade to eliminate future accumulation of surface water and the resulting deposition of sediments.

In August and September 2007 piping modifications were made to reduce and re-route storm water runoff entering the West Pond. A sump was installed in the southeast corner of the West Pond and the four drain lines were extended to allow discharge into the sump. A pump was installed to transfer the water from the sump to the ASTs for use in the Land Application program. Approximately 450 feet of discharge pipe was connected to the sump and extended the full length of the West Pond to Krehbiel Pond. The pipe directs flow during high flow periods from the West Pond to Krehbiel Pond where the existing Krehbiel Pond pump transfers the water to the East Effluent Pond. Following these modifications, the only water entering the West Pond is precipitation that falls directly on the pond and areas immediately adjacent. Interim measures undertaken at the West Pond were documented in *Letter Report Interim Measures Activities* dated September 1, 2006.

### 4.2.4 Krehbiel Pond

The Krehbiel Pond is located northwest of the former Ammonium Nitrate Production Area and encompasses approximately 0.8 acres. Soil samples collected during Site Characterization activities had reported concentrations of ammonia ranging from 21.2 mg/kg to 718 mg/kg and total nitrogen ranging from 377.2 mg/kg to 1,045 mg/kg. Groundwater analytical results showed that nitrate concentrations were highest near West Pond and Krehbiel Pond, ranging from 0.15 mg/L to 33,310 mg/L in the silty clay unit. Ammonia concentrations in groundwater were also highest near West Pond and Krehbiel Pond, ranging from less than 0.06 mg/L to 51,640 mg/L in the silty clay unit.

Between May 14 and June 15, 2006, approximately 4,200 cubic yards of nitrogen-impacted sediment were excavated from the Krehbiel Pond and placed in the East Lime Pond. Approximately 2,700 cubic yards of backfill material, obtained on-site, was used to restore an adequate grade for proper surface water flow and erosion control. Interim measures undertaken at the Krehbiel Pond were documented in *Letter Report Interim Measures Activities* dated September 1, 2006. Currently, surface water that accumulates, including storm water runoff directed through the West Pond to Krehbiel Pond, is transferred by the existing pump in Krehbiel Pond through piping to the East Effluent Pond.

## *4.3 Area D*

### 4.3.1 Catalyst Landfill Excavation

The Catalyst Landfill was located in the northern portion of Area D and was constructed to receive spent catalysts produced in various operations at the Site. The landfill measured approximately 150 feet by 25 feet by 15 feet deep, was unlined, and operated between 1981 and 1989 on an as-needed basis with the approval of KDHE. The landfill was covered with surrounding soils when not active and upon closure.

Between May 14 and June 15, 2006, approximately 815 cubic yards of catalyst material and soil were excavated from the Catalyst Landfill area. Excavated material was transported and disposed at a permitted special waste landfill. The excavated area was backfilled with clean fill material and seeded with native grasses. Sample results of the excavation area following removal of the catalyst indicate that the catalyst material has been successfully removed from the Catalyst Landfill. Interim measures undertaken at the Catalyst Landfill were documented in *Letter Report Interim Measures Activities* dated September 1, 2006.

### 4.3.2 Area D – Spill Pond and Oil Pond

Residual petroleum hydrocarbons were detected in the Spill and Oil Ponds during site characterization. Therefore, the selected interim remedial measure was to backfill with clean soil, grade to prevent ponding, and seed with native grasses.

The Spill Pond contained approximately 12 inches of water from precipitation events, so a pump was used to dewater it between May 10 and May 15, 2006. Approximately 25,000 gallons of water was directed to the main storm water ditch that flows through the Site and enters the Effluent Pond system. Once the Spill Pond was dewatered, approximately 2,000 cubic yards of on-site fill material was used to restore surface grade for the Spill and Oil Ponds. The areas were then seeded with native grasses. Interim measures undertaken at the Spill and Oil Ponds were documented in *Letter Report Interim Measures Activities* dated September 1, 2006.

### 4.3.3 Chrome Reduction System (CRS)

The CRS continues to be subject to the RCRA Post-Closure Permit pending return of pH conditions in the groundwater to between 6 and 9. Contaminated soil was removed when the CRS was taken out of service. Groundwater monitoring and reporting have been conducted at the CRS since 1982. The permit was issued in 1993, and due to a timely submittal of a renewal application in 2002, it remains in effect. The permit identifies monitoring points to provide groundwater information in the area, including immediately down-gradient of the former acid pond. PH is the only remaining contamination issue for the CRS as chromium concentrations are within acceptable limits in the monitoring wells; therefore KDHE has determined that the CRS will no longer require Post-Closure Care following rectification of the low pH condition.

To help mitigate the low pH condition, a work plan was submitted to KDHE in June 2005, and an infiltration system was constructed in May 2006. Injected potable water flowed through the CRS subsurface in an effort to accelerate the mitigation of low pH conditions. Potable water introduced by gravity flow to the infiltration system amounted to approximately 100,000 gallons per month. The system was monitored daily, with pH measurements recorded weekly, but the system appeared to have limited beneficial effect. An amendment to the potable water infiltration system was installed in June 2007 using sodium bicarbonate in an effort to buffer the injected water and neutralize the subsurface media more effectively. Groundwater monitoring data collected since start up of the infiltration system in 2006 indicates the injection program has not been effective.

The estimated flow rate of groundwater through the CRS was calculated during the closure investigation to be approximately 20 feet per year on average under natural hydraulic gradient conditions. The area of low pH groundwater is approximately 240 feet long. Post-Closure Care will continue under reduced monitoring requirements until the pH of groundwater recovers.

## *4.4 Summary of Other Interim Measures Implemented*

Other interim measures have included planning and implementation of an off-site land application program to beneficially utilize nitrogen-impacted groundwater and storm water. Impacted water not directly pumped into ASTs is directed to the Rundown Pond and Overflow Pond and transferred to the on-site ASTs for storage. The impacted water is pumped from the ASTs and re-used in center pivot irrigation systems for a sod farm and for various crops located north of the Kansas River. Modifications were made to on-site storm water drainage to segregate impacted storm water runoff for use in the land application program. Piping modifications were also made to the groundwater containment system to allow capture of groundwater impacted by nitrogen compounds through interceptor trenches to be pumped directly to the ASTs for use in the land application program.

Other measures completed include the following:

- The 500-gallon septic tank located at the northwest portion of the Site near the Bag Warehouse has been emptied and filled with inert material.

- The Imhoff Tank, a 39,000-gallon below-grade concrete tank designed to treat domestic and sanitary sewer wastewater, was cleaned out and currently accepts only domestic wastewater from the on-Site Laboratory and Administration Building.

- Subsurface lime sludge lines previously used to transfer lime sludge from the Cold Lime Softening Unit to the West and East Lime Ponds were plugged and abandoned in place to provide secure containment of the materials placed in the ponds.

- Out-of-service water distribution and major industrial process lines have been located, flushed, and capped in order to protect the City of Lawrence and off-Site well field water supplies.

- Asbestos-containing materials (ACM) were removed from the Site except for the administration buildings and laboratory. Over 15,000 feet of ACM underground piping remains on site and will be removed as necessary as the Site is developed.

- The large AST has been inspected, cleaned, and repaired for use in the land application program.

- Groundwater monitoring and containment systems were evaluated, resulting in the abandonment of 57 monitoring wells, installation of five new monitoring wells, and repair and rehabilitation of six monitoring wells.

- Pipelines from the ASTs to the land application sites were pressure tested to ensure integrity.

# 5.0 SUMMARY OF SITE RISKS

## *5.1 CONTAMINANTS OF CONCERN*

KDHE has developed chemical-specific and site-specific cleanup goals called Risk-Based Standards for Kansas (RSK) using guidance, methods, and directives from EPA and other technical sources. These RSK goals are concentrations of individual contaminants that have been calculated using generic physical and chemical parameters and generalized exposure assumptions that are considered protective of human health and the environment. RSK goals have been developed for contaminants in soil and in groundwater and for both residential and non-residential exposure settings. In general, RSK goals for a residential exposure setting are lower (more protective) than those for a non-residential exposure. RSK goals serve as useful benchmarks for comparison to site contaminant concentrations to evaluate, on a screening level, whether site contamination may pose a potential risk to human health if exposure occurs. More information on the development and use of KDHE's RSK manual is available at http://www.kdheks.gov/remedial/rsk_manual_page.htm. Comparison to KDHE's RSK goals and other values developed by KDHE and EPA were used to evaluate those constituents that pose a potential risk to human health, the environment, or natural resources at and near the Site.

The primary contaminants of concern at the Site are nitrate-nitrogen (nitrate) and ammonia-nitrogen (ammonia), fertilizer compounds spilled or disposed at the Site over years of production. Nitrate and ammonia have been identified at elevated concentrations in groundwater, soil, sediments, and surface and storm water at the Site.

Arsenic has been detected at elevated concentrations in some pond sediments and soils at the Site and in groundwater in the vicinity of the northern ponds. Arsenic was detected in groundwater at concentrations above the federal drinking water standard for public water supplies during the Site Characterization activities in 2005, but these results were not reproduced during subsequent sampling after monitoring wells at the Site were reconditioned, suggesting the detections in groundwater may have been related to sedimentation of the wells. Some arsenic at the Site in soil, sediments, and groundwater is likely naturally occurring. Naturally-occurring arsenic is well documented in soil and rocks in this portion of Kansas.

Other constituents, including fuel and solvent compounds, other metals, and PCBs have been detected at the Site. None of these contaminants were detected above KDHE's non-residential RSK goals. Total chromium results exceeded the residential RSK goal in some sediment samples in the Northern Ponds Area, but the results were below the non-residential RSK goal. Chromium was not detected at significant concentrations in other portions of the Site in groundwater, soil, or surface or storm water. Mercury was detected at a concentration above the residential RSK goal but below the non-residential RSK goal in only one sample in the Northern Ponds Area and is not considered further in this CAD. Other compounds detected during the 2005 Site Characterization investigation were present at concentrations below their respective residential RSK goals. Because they are detected infrequently and at concentrations below the non-residential RSK goals, they are not further discussed in this CAD. Detailed information concerning historical contaminant detections at the Site is included in various investigation documents, particularly the 2005 Site Characterization Report.

## *5.2 TOXICITY ASSESSMENT*

The toxicity assessment presents the potential human health effects with respect to exposure to site contaminants in each environmental medium (groundwater, soil, sediment, surface and storm water) at the Site.

As a pure product or as a fertilizer, ammonium nitrate can cause irritation through ingestion, inhalation, and contact with the skin and eyes. The primary target of nitrate toxicity, however, is the red blood cell. When nitrates are introduced into the body, nitrate is converted to nitrite, which can reduce the ability of red blood cells to transport oxygen. The resulting condition is methemoglobinemia, to which infants are particularly susceptible. Nitrate is a normal component of the human diet. A large proportion of the typical daily intake by an adult in the United States comes from the natural nitrate content of vegetables such as beets, celery, lettuce and spinach. With respect to environmental contamination, nitrate can be introduced to the human body through consumption of contaminated water or through ingestion of contaminated soil. EPA has not established toxicity values for exposure to nitrate through inhalation of contaminated dust or dermal absorbtion of nitrate from contaminated soil due to inadequate toxicity data for these routes of exposure.

Exposure to high levels of ammonia may cause irritation to skin, eyes, lungs, and throat. Inhalation of extremely high concentrations of ammonia can cause lung damage. EPA has not established toxicity values for exposure to ammonia through ingestion or dermal contact with soil due to inadequate toxicity data for these routes of exposure.

Exposure to inorganic arsenic can cause various health effects, such as irritation of the stomach and intestines, decreased production of red and white blood cells, skin changes, and lung irritation. It is suggested that the uptake of significant amounts of inorganic arsenic can increase the chances of cancer development, especially the development of skin cancer, lung cancer, liver cancer and lymphatic cancer. Arsenicosis is a chronic illness resulting from drinking water with high levels of arsenic over a long period of time. It results in various health effects including skin problems, skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure, and reproductive disorders. Exposure to inorganic arsenic in the environment could occur through ingestion of contaminated soil or groundwater, inhalation of contaminated dust, or, to a lesser extent, through dermal absorbtion.

Chromium can exist in different forms in the environment. Chromium(III) is an essential nutrient that helps the body use sugar, protein, and fat. Breathing high levels of chromium(VI) can cause irritation to the lining of the nose, nose ulcers, runny nose, and breathing problems, such as asthma, cough, shortness of breath, or wheezing. The main health problems seen in animals following ingestion of chromium(VI) compounds are irritation and ulcers in the stomach and small intestine and anemia. Chromium(III) compounds are much less toxic and do not appear to cause these problems. Sperm damage and damage to the male reproductive system have also been seen in laboratory animals exposed to chromium(VI). Skin contact with certain chromium(VI) compounds can cause skin ulcers. Allergic reactions consisting of severe redness and swelling of the skin have been noted. Chromium(VI) compounds are known human carcinogens and have been shown to cause lung cancer via inhalation and stomach tumors via consumption of contaminated drinking water. Exposure to chromium in sediments could occur through ingestion of contaminated sediments or inhalation of fugitive dust from exposed sediments.

## *5.3 Potential Human and Environmental Exposures*

The potential means of exposure to known contaminants at the Site discussed above, when considered in combination with the occurrence and magnitude of contamination, determine potential human exposures posed by Site contamination. Where those exposures exceed acceptable risk-based goals or other regulatory standards, some action must be taken to prevent human exposure or reduce site contamination. This discussion is grouped by environmental medium.

### 5.3.1 Groundwater Pathway

Potential human exposure to Site contaminants in groundwater could occur primarily by:

1) direct or incidental ingestion of contaminated water produced from a groundwater well,
2) direct or incidental ingestion by industrial or farm personnel of contaminated water applied to the surface through the land application system.

Current and future consumption of groundwater on Site is not considered due to the availability of a municipal water supply. Nevertheless, consumption of nitrate-contaminated groundwater on many portions of the Site would pose an unacceptable risk.

Private drinking water wells are located immediately downgradient of the Site in an area that would likely be contaminated absent the ongoing operation of the Site groundwater containment system. EPA has established a drinking water standard for nitrate in public water supplies of 10.0 mg/L. The Kansas River alluvial aquifer immediately downgradient of the Site is a significant source of private and public drinking water supply in the region and should be protected to prevent it becoming contaminated in excess of the drinking water standard of 10.0 mg/L.

The risk of exposure by industrial or farm workers to land application water is minimal. Delivery of the water to the land application sites is performed by remote operation of valves and pumps that do not require contact with the water. As such, the potential for direct or incidental ingestion of land application water is considered negligible.

No screening levels or preliminary remediation goals are available for exposure to ammonia in groundwater.

In terms of environmental risk, nitrate- and ammonia-contaminated groundwater has the potential to seep to the surface and further degrade soil, sediment, and surface water quality at and downstream of the Site. If not contained, contamination from the Site might ultimately flow through the Kansas River alluvial aquifer and discharge to the river.

### 5.3.2 Soil and Sediment Pathway

Potential human exposure to Site contaminants in surface and subsurface soils and sediments could occur primarily by:

1) incidental ingestion of soil or sediment,
2) inhalation of wind-borne particulates, or
3) inhalation of contaminant vapors from subsurface soil or sediments, as during excavation for construction.

There are currently no screening levels available regarding potential health effects caused by inhalation or dermal absorbtion of nitrate from soil or sediment. Ingestion of nitrate-contaminated soil or sediment can cause potential health effects, but the screening level developed by EPA for this mode of exposure is greater than the concentrations found at the Site. Because nitrate-containing compounds in soil and sediment are very soluble, they tend to migrate with water. Therefore, the primary concern with nitrate in soil and sediment at the Site is not human health, but rather the potential for nitrate to migrate to ground and surface water, where it can pose an exposure threat to human and environmental receptors and threaten the quality of the Kansas River alluvial aquifer. Nitrate and ammonia contamination in surface and subsurface soil and sediment could also limit vegetative growth of grasses and other cover at the Site.

Low levels of ammonia in soil are taken up by plants or transformed by microbes into nitrate and nitrite. High levels of ammonia can pose a health risk to humans when exposed. KDHE has not developed RSK goals for ammonia. EPA Region 7 developed preliminary remediation goals (PRGs) for ammonia in soil or sediment for this Site, assuming direct contact of a human receptor through inhalation of ammonia vapors from contaminated soil or sediment. PRGs were determined for three inhalation exposure scenarios – industrial outdoor worker, construction worker, and resident. The primary exposure pathway of concern for ammonia in soil or sediment is by construction and underground utility workers in close proximity with surface and subsurface soils or sediments, such as in an excavation or trench. This construction worker exposure scenario resulted in the lowest PRG value for ammonia, 385 milligrams per kilogram, a concentration that is exceeded in surface and subsurface soil and sediment at several locations across the Site. The PRG values for industrial outdoor worker and resident scenario exposures to ammonia were also exceeded in surface and subsurface soil and sediment at some locations.

Arsenic was found in surface and subsurface soils and sediments throughout the Site at concentrations that exceed the residential RSK goal but are generally below the non-residential RSK goal. Two sediment samples in the East Lime Pond in the Northern Ponds Area exceeded the non-residential RSK goal. While some arsenic in soil and sediment at the Site is likely naturally-occurring, some may also be attributable to former Farmland operations. Residential exposure to arsenic in soil and sediment at the Site could pose a potential human health risk.

Chromium was detected in sediments in some of the northern ponds at concentrations that exceed the residential RSK goal but are below the non-residential RSK goal. Residential exposure to chromium in sediment at the Site could pose a potential human health risk.

#### 5.3.3 Surface and Storm Water Pathways

Potential human exposure to Site contaminants in surface and storm water could occur primarily by direct contact with water contained in the various pond systems or runoff from various surfaces at the Site. Potential human exposure could occur primarily by incidental ingestion of contaminated storm and surface water.

Although ingestion of surface and storm water is possible, the ponds and the storm water will not be used as a water supply for drinking. Therefore, the potential for nitrate exposure resulting from incidental ingestion of surface and storm water is expected to be minimal.

No information on chronic health effects related to dermal absorbtion of ammonia from water is available, and no screening levels or preliminary remediation goals were found for exposure to ammonia in surface and storm water. High levels of ammonia in surface water can be toxic to aquatic life, but the level is dependent on pH conditions. The State of Kansas established surface water quality criteria for ammonia in surface water. At neutral pH of 7.0, the ammonia criterion is 36.1 mg/L.

Discharge of nitrogen compounds in storm water ultimately results in the loading of nutrients in the Kansas River. In excess amounts, this can cause an increase in aquatic plant growth and changes in the flora and fauna of the aquatic ecosystem, which can result in hypoxia (low dissolved oxygen levels). High nitrate levels in surface water can also directly affect fish and warm-blooded animals. KDHE has undertaken a state-wide effort, the Surface Water Nutrient Reduction Plan, to reduce discharges of nutrients to surface water in Kansas.

### *5.4 CLEANUP GOALS*

KDHE's chemical-specific RSK values, EPA's calculated Preliminary Remediation Goals, and relevant drinking water and surface water quality standards form the goals and basis for cleanup and Site use restrictions.

#### 5.4.1 Groundwater Cleanup Goals

The EPA has established a drinking water standard of 10.0 mg/L nitrate as nitrogen in public drinking water supplies, which KDHE has adopted as the groundwater cleanup goal. The EPA has not established a drinking water standard for ammonia.

#### 5.4.2 Soil and Sediment Cleanup Goals

RSK soil levels for nitrate and ammonia were developed to be protective of soil contamination migrating to groundwater. RSK goals for total nitrate plus ammonia are:

<u>Surface Soil</u>

- 85 mg/kg in the upper eight inches of soil in areas where no vegetation is present

- 200 mg/kg in the upper 24 inches of soil where vegetation is present

Subsurface Soil

- 40 mg/kg below eight inches of soil in areas where no vegetation is present
- 40 mg/kg below 24 inches of soil where vegetation is present

Previous investigations have identified numerous areas of surface and subsurface soil and sediment contaminated by nitrate and ammonia at concentrations above RSK goals.

EPA calculated Site-specific PRGs for ammonia in soil based on the inhalation exposure pathway. The Site-specific PRGs are 385 mg/kg ammonia for the construction worker exposure scenario, 4,500 mg/kg for the industrial outside worker exposure scenario, and 1,060 mg/kg for the residential exposure scenario. These values are exceeded in surface and subsurface soil and sediments at various locations throughout the Site.

The KDHE RSK goals for arsenic in soil are 11 mg/kg for soil in a residential exposure setting and 38 mg/kg for soil in a non-residential exposure setting.

The KDHE RSK goals for total chromium [chromium(III) plus chromium(VI)] in soil are 390 mg/kg for soil in a residential setting and 4000 mg/kg for chromium in a non-residential exposure setting.

### 5.4.3 Surface and Storm Water Cleanup Goals

The Kansas Surface Water Quality Standard for nitrate (as nitrogen) is 10.0 mg/L for a domestic water supply use category. While there is no standard available for ammonia in the domestic water supply use category, the standard for aquatic life criteria for ammonia in surface water is 36.1 mg/L at a pH of 7.0. Currently, storm water flows through an existing collection system to the East and West Effluent Ponds and is then discharged through National Pollutant Discharge Elimination System (NPDES) outfall 001B. The NPDES permit for the Site has discharge limits for ammonia and nitrate. The long-term goal for surface water quality leaving the Site is to restore it to the quality of surface water entering the Site, currently less than 10.0 mg/L of nitrate (as N) and 2.0 mg/L of ammonia (as N). The purpose of the surface water cleanup goal is to prevent further degradation of surface water, primarily the Kansas River, by controlling the discharge of impacted water from the Site.

## *5.5 REMEDIAL ACTION OBJECTIVES*

Remedial Action Objectives (RAOs) are medium-specific goals for protecting human health and the environment. RAOs combine the contaminants of concern, potential exposure pathways and receptors, and cleanup goals and form the basis for development and evaluation of future cleanup actions at the Site.

### 5.5.1 Groundwater RAOs

For Human Health:

Prevent ingestion of on- or off-site groundwater having nitrate contamination in excess of the federal drinking water standard for public water supplies of 10.0 mg/L.

For Environmental Protection:

Contain nitrate- and ammonia-contaminated groundwater on-Site to prevent degradation of the downgradient Kansas River alluvial aquifer.

### 5.5.2 Soil and Sediment RAOs

For Human Health:

Prevent inhalation of fugitive vapors from surface and subsurface soil contaminated with ammonia in excess of the Site-specific PRGs.

Prevent ingestion, inhalation, or direct contact with soil contaminated with arsenic in excess of relevant RSK goals.

Prevent ingestion, inhalation, or direct contact with sediment contaminated with total chromium in excess of relevant RSK goals.

For Environmental Protection:

Prevent migration of contaminants that would result in groundwater contamination in excess of 10.0 mg/L nitrate or surface water contamination in excess of background quality for nitrate and ammonia.

### 5.5.3 Surface and Storm Water RAOs

For Human Health:

Prevent ingestion of contaminated surface or storm water contaminated with nitrate in excess of the federal drinking water standard for public water supplies of 10.0 mg/L.

For Environmental Protection:

Restore surface water and storm water quality leaving the Site to background quality for nitrate and ammonia.

## *5.6 Site-Specific Considerations*

Note that RAOs can be attained through reduction of contaminant concentrations or through preventing exposure with site use controls, or both. The following considerations factored into KDHE's development of the proposed cleanup measures for the Site:

- Limited funding is available in the remediation and administrative trust funds for the Site.
- With the dissolution of Farmland Industries, no responsible party is available at this time to supplement the trust funds.
- Historical and current land use is industrial.

- Land use restrictions have been established for previously closed portions of the Site (landfills) and Site-wide use restrictions will be placed on the Site to limit future land use to prevent unacceptable human exposures.
- The primary contaminants at the Site are nitrate and ammonia which are subject to rapid degradation at the soil surface and will leach into the groundwater from contaminated soils.
- Ammonia in soil will eventually convert to nitrate and nitrite through a process of nitrification.
- An existing groundwater containment system will capture nitrate leached from soil to groundwater, preventing off-site migration.
- Elevated ammonia concentrations present in shallow soils (0 to 6 feet) present a potential risk to human health through the inhalation of ammonia that volatilizes from the soil.
- Elevated nitrate and nitrite concentrations present in groundwater present a potential risk to infants through ingestion of drinking water contaminated by nitrate and nitrite.
- No drinking water wells are located on the Site. Drinking water wells are located downgradient of the Site and sampled on a periodic basis.
- Elevated nitrate concentrations present in surface soil will affect the nitrate mass loading levels associated with storm water runoff from the Site.
- Surface water contaminated with nitrate and ammonia can be isolated, collected, and land applied for beneficial reuse.

## 6.0 SUMMARY OF REMEDIAL ALTERNATIVES AND THE PREFERRED REMEDIAL ALTERNATIVE

The remedial actions proposed for this Site were developed and evaluated based on the results of site characterizations, development of remedial action objectives, and evaluation of various remedial alternatives. The remedial actions have been categorized for staggered implementation based on several issues: 1) the responsible party (Farmland Industries) is in bankruptcy, 2) there is a limited amount of funding available in the Trust to remediate all environmental contamination issues at the property, 3) land use of the property will remain as non-residential based on both zoning and environmental conditions identified at the Site, 4) the Trust is interested in selling the property for redevelopment and reuse, and 5) various parties have expressed an interest in investing in and redeveloping the property. KDHE acknowledges that prospective purchasers may have specific intentions with respect to the final configuration of site features, and that deferral of some cleanup actions is necessary to allow coordination of the cleanup and redevelopment activities. Any purchaser of the property will be required to enter into a Consent Agreement with KDHE that will ensure their participation in and contribution to the cleanup.

The remedial actions identified for the Site fall into the following three categories:

1. Primary Remedial Actions – remedies to be either continued and/or implemented immediately using funding from the Remediation Trust:
   a. Continue operation and enhancement of the groundwater monitoring network;

   b. Continue operation and enhancement of the groundwater containment system including land application of impacted water;
   c. Record and file with the County Register of Deeds Office LURs to control future uses and activities at the Site; and
   d. Continue Post-Closure monitoring of the CRS in accordance with the requirements of the KDHE Bureau of Waste Management.

2. Redevelopment Actions – to be implemented in coordination with future Site redevelopment plans and/or by funding from the Administrative Trust:
   a. Modify infrastructures, operations, and maintenance of storm water management systems to meet the needs of future redevelopment plans and maintain current NPDES requirements, as well as those incorporated into future NPDES permits. This includes removal of sludge from the East and West Effluent Ponds so they can be used for future non-contact storm water detention.

3. Secondary Remedial Actions – to be implemented based on available funding in the Remediation and Administrative Trusts and/or by a prospective purchaser:
   a. Excavation and management of impacted soils in select areas of the Site to improve storm water runoff quality;
   b. Excavation and management of impacted soils to accommodate future redevelopment or construction;
   c. Final closure of the northern ponds, including the Overflow Pond.

## *6.1 PRIMARY REMEDIAL ACTIONS*

### 6.1.1 Enhancement of the Groundwater Monitoring Network

The first priority is maintaining hydraulic control of groundwater impacted by nitrogen compounds using the existing groundwater containment system, with enhancements, disposal of the impacted water (included impacted storm water runoff) through the existing land application system, and continued monitoring using the existing groundwater monitoring network with several additional monitoring locations. Proposed enhancements to the existing groundwater containment system include the installation of an interceptor trench in the Central Ponds area to capture groundwater seepage that impacts surface water quality, the installation of a sump/pump system associated with the Dam Pond, and the installation of an alluvial aquifer pumping well north or northwest of the Bag Warehouse.

Continued operation of the enhanced groundwater containment system is required to ensure groundwater impacted by nitrogen compounds does not migrate off-site and impact the Kansas River alluvial aquifer or contaminate private drinking water wells located downgradient of the containment system. Groundwater monitoring must continue to ensure that on-site contamination is being hydraulically contained.

Historical monitoring data indicates the existing groundwater containment systems are effectively capturing shallow groundwater and preventing migration into the deeper alluvial aquifer located north and northeast of the Site; however, two potential concerns were identified and evaluated. First, migration of elevated nitrate concentrations from Sandstone Hill into the alluvial aquifer appears to be taking place to the west of the existing North and South Interceptor Trenches and near the west end of the Bag Warehouse building. Secondly, the North and South Interceptor Trenches may not be constructed deep enough to intercept all groundwater migrating from Sandstone Hill to the silty clay unit and alluvial aquifer. Presently, water exiting Sandstone Hill can migrate through sandy overburden sediments (which are present between clayey overburden and the sandstone unit) directly into the alluvial aquifer. Based on drilling logs from this area, the sandy overburden and alluvial aquifers are connected laterally.

The preferred remedial alternatives to address the identified inadequacies in the existing groundwater containment system are presented below.

#### *6.1.1.1 New Recovery Well*

Remedial alternatives were developed in the RAP based on the conclusion that elevated nitrate concentrations are entering the alluvial aquifer from Sandstone Hill and that containment of this impacted groundwater is necessary to protect the alluvial aquifer system. Recent KDHE investigation data (*KDHE Data Gap Investigation Report,* dated October 27, 2008) indicates the existing system is adequately controlling migration to the north of Krehbiel Pond, but that off-site migration may be occurring in the northwest corner of the Site.

KDHE has determined that the preferred remedial alternative to address groundwater in this area is the installation of three additional monitoring wells near sample location WE-1 located to the north of the Bag Warehouse and SW-10A located just west of the Bag Warehouse. The existing and newly installed monitoring wells will be monitored quarterly and the data evaluated to determine if a pumping well is needed. If needed, the new pumping well will be constructed and placed into operation at a location to be determined depending on analytical data. Expansion of the shallow groundwater monitoring network in the area of the Bag Warehouse will provide additional information needed to confirm effective capture of overburden groundwater. The estimated cost for installation of new monitoring wells, new recovery well with piping, and monitoring is $67,675.

#### *6.1.1.2 Interceptor Trench – Central Ponds Area*

Subsequent to the completion of interim actions, storm water and shallow groundwater seepage from the Sandstone Hill area has continued to intermittently flow into the area of the former Central Ponds. Crystallized residue from evaporated seep water has also been observed on the ground surface near the former ponds. Analytical results from seeping groundwater indicated ammonia at 2,400 mg/L and nitrate at 4,500 mg/L. Analysis of samples of the crystallized residue suggests that it is comprised of ammonium nitrate.

KDHE has determined that the preferred remedial alternative for contaminated seepage in this area is installation of an interception trench with gravity discharge of water to existing ponds in Area B for eventual utilization through land application. The trench will prevent further seepage of nitrogen compounds from the hillside to the surface, and it will thus eliminate a source of surface soil, surface water, and storm water impacts. Spot removal of impacted soils will be undertaken in the area of and along the service road north of the former pond. The estimated cost is $53,200.

#### *6.1.1.3 Dam Pond Sump*

Current data indicates that storm water runoff in the drainage at the northwest corner of Area A typically contains 100 to 700 mg/L nitrate. Water is currently diverted into a pipe which leads to the Krehbiel Pond in Area B. From there, water is pumped to the West Extension Pond and the West Effluent Pond. When the West Effluent Pond is taken out of service, modifications will be made to capture the water diverted by the Dam Pond for land application. It is anticipated that the capture of surface water in this drainage will continue until soil remediation is completed in the Sandstone Hill/Condensate Pond area.

Storm water runoff to the Dam Pond will be improved by the remedial action carried out in the Sandstone Hill/Condensate Pond area. Therefore, no new remedial action is recommended for surface water in the Dam Pond area. Because impacted shallow groundwater may still create high nitrate levels in the drainage surface water, the Dam Pond should be left in place and maintained in functioning condition. KDHE has determined that modifications will be made to capture the water from the Dam Pond for land application from the ASTs rather than diversion to the Area B ponds. The estimated cost for installing the sump, pump, piping, and providing electrical service for the pump is $51,550.

### 6.1.2 Land Application Program

The existing land application program is important for management of fertilizer-contaminated water generated by the groundwater containment system. Land application or some other disposal method will be required as long as this groundwater containment system is operating. The volume of water to be land applied is expected to increase initially because of the increased collection of storm water runoff and collection of groundwater seepage. The volume of storm water collected for land application is anticipated to decline over time as the storm water quality improves. It is highly likely that a point in time will be reached when the land application for beneficial use of the nitrogen compounds in the water will no longer be economically feasible due to lower nitrate concentrations and the resultant increase in water volumes required to deliver the desired mass of nitrogen.

The estimated long-term costs are $50,100 annually. The system is estimated to generate a volume of 24 million gallons per year. The estimated long-term costs for periodic maintenance activities, including final decommissioning, are estimated at $575,600. A detailed breakdown of the activities and costs are provided in the RAP.

### 6.1.3 Land Use Restrictions

The KDHE has determined that LURs are a preferred remedial alternative to control certain activities and land uses in order to protect human health and the environment and ensure proper management of contaminated soil and groundwater. A soil management plan will be developed and available to future users of the property to provide guidance in the handling and movement of potentially contaminated soil. The Trustee will apply to KDHE's Environmental Use Control Program for LURs.

#### *6.1.3.1 Part of Area F – Southeast Site Area*

No additional remedial action was evaluated for the south and eastern two-thirds of Area F as the contamination is limited and seems to be confined to areas of buried material. KDHE has determined that the proposed remedial alternative of no additional action is acceptable, with the exception of existing LURs for areas of buried material and Site-wide LURs. The northwestern and western portions comprising 22 acres in Area F will require specific LURs addressing future excavation and management of soil and buried material in addition to Site-wide LURs.

It has been demonstrated through long-term monitoring and site characterization activities that the groundwater in Area F will ultimately migrate to the north end of the Site and be captured by the existing groundwater containment system. The area will also fall under the Site-wide LUR which will prohibit the installation of water wells on the Site and limit residential zoning at the Site.

#### *6.1.3.2 Area D – Paint Shop Area, Boiler Furnace/Fuel Oil Storage Area, Old Ammonia Plant, Ammonia Production Primary Reformer Area, Nitric Acid Area*

KDHE has determined that the proposed remedial alternative of no additional remedial action is acceptable for these areas based on the limited magnitude and extent of contamination in surface and subsurface soils and the lack of groundwater. Potential exposures to contamination in soils will be managed using LURs.

#### *6.1.3.3 Area D – Urea #2 Area*

**Surface Soils**

Urea #2 Area consists of approximately 3.2 acres of surface soils with a volume of 10,500 cubic yards of affected soil in the upper two feet of the surface. KDHE has determined that the preferred remedial alternative for nitrogen impacts in surface soils is to maintain existing pavement in its current condition and continue current surface water runoff management activities. Nitrogen concentrations are expected to continue to decrease by natural processes and percolation of water through the subsurface. LURs would be needed to:

a) prevent removal or disturbance of any pavement or impermeable surface or require that they be replaced;

b) require proper management/disposal of soils excavated for redevelopment purposes; and

c) require repair of incidental damage or weathering of pavement.

Future redevelopment of the area would be subject to these restrictions or to redevelopment of alternative methods for management or remediation of contaminated soil. This remedy was selected based on the high cost of the other alternatives and the Site's demonstrated ability to meet surface water discharge limits under the current plant configuration and water management programs. The estimated cost for this remedy is $90,000 during the 30-year period.

**Subsurface Soils**

Concentrations of total nitrogen above RSK goals are present in subsurface soils within the central portion of the Urea Plant and the south side of the Urea Warehouse. Highest concentrations were generally found between the Urea Plant Production Area and the Urea Vault. The waste disposal area identified as the Original Landfill is located in the vicinity of the Urea Plant and Urea Vault.

Impacted subsurface soils cover approximately 4.4 acres within the central portion of the Urea Plant and Bulk Warehouse. The depth of impacted soil above the RSK goal extends to the bedrock surface (up to 27 feet below grade) within the central portion of the Urea Plant and to 9 feet below grade within the northeast portion of the Ammonia Plant, located south of the Urea Plant. Approximately 77,700 cubic yards of impacted subsurface soil (including the waste contained in the Original Landfill) are estimated beneath the Urea Plant.

KDHE has determined that the preferred remedial option for nitrogen impacts in the subsurface soils based on current Site use is to use the same LURs identified for the surface soils. The selected remedial alternative for subsurface soils within the urea and ammonia plants is based on the following premises:

- Potential exposures to nitrate- and ammonia-contaminated soils can be prevented with LURs.

- Impacted shallow groundwater in bedrock and overburden units is contained within the Site and is captured by the existing groundwater control system. Subsurface soils will not come into contact with surface water or storm water runoff and will not create an off-site transport problem.

#### *6.1.3.4 Area A – Northeast Production and Bag Warehouse Areas*

The nitrogen impacts in the soil in this area are likely the major contributor to the observed storm water runoff impacts in the Area B ponds and shallow groundwater impacts observed in the groundwater interceptor trench and French drain systems.

**Surface Soils**

Surface soil above the RSK goal for nitrate plus ammonia covers an area of approximately 25.4 acres. While approximately 82,000 cubic yards of impacted surface soil are estimated for the evaluation, much of the affected surface soil area is covered by gravel or concrete pavement.

KDHE has determined that the preferred remedial alternative is to take no additional action, maintain existing pavement, and continue current surface water runoff management activities. Nitrogen concentrations would continue to decrease by natural processes and percolation of water through the subsurface. LURs will be needed to:

a) prevent removal or disturbance of any existing pavement or impermeable surface or require that they be replaced,

b) require proper management/disposal of soils excavated for redevelopment purposes, and

c) require repair of incidental damage or weathering of pavement.

Future redevelopment of the area would be subject to these restrictions or to development of alternative methods for management or remediation of contaminated soil. No additional cost is anticipated beyond what is included under the storm water operation and maintenance budget detailed in the RAP.

**Subsurface Soils**

Subsurface soil above the RSK goal for nitrate plus ammonia covers approximately 28.0 acres, encompassing more area north of the Bag Warehouse and east of the nitrate warehouse. Impacts of total nitrogen in excess of the RSK goal extend to bedrock in many places and to depths up to 31 feet bgs. The highest concentrations were generally found in the areas between the former nitrate plants and three former nitrate warehouses. Using an estimated average impacted subsurface soil thickness of 20 feet across the area of interest; the calculated volume of impacted subsurface soil is approximately 908,000 cubic yards.

KDHE has determined that the preferred remedial alternative is to use the same LURs identified for the surface soils. Remediation of subsurface soils would likely be infeasible given the depth, distribution, and low permeability of these sediments. Potential exposure to subsurface nitrate and ammonia impacts can be prevented by LURs. Subsurface soil impact to shallow groundwater will be contained within the Site or captured at the Site boundary by the existing groundwater control system (interceptor trenches and pumping wells). No additional cost is anticipated beyond continued operation of the groundwater system.

#### *6.1.3.5 Groundwater-Contaminated Areas Recommended for LUR-Only Action*

##### 6.1.3.5.1 Area A – Northeast Production Area

Sampling of monitoring wells during the Site Characterization demonstrated that nitrate concentrations up to 3,820 mg/L and ammonia concentrations up to 2,740 mg/L are present in the silty clay groundwater unit beneath the Northeast Production Area. A French drain system constructed for shallow groundwater interception exists along the north edge of the Site. This drain system intercepts shallow groundwater migrating from the Northeast Production Area before it reaches the Kansas River aquifer.

The selected remedial alternative for shallow groundwater in the area is based on the following premises for Area A:

- Shallow groundwater in the overburden and bedrock will not produce a sustainable yield of groundwater.

- Site-wide shallow groundwater flow is toward the north and exits the Site along the north property boundary.

- Existing groundwater interception systems are effective in preventing migration of shallow groundwater to the alluvial aquifer beneath the floodplain.

KDHE has determined that the preferred remedial alternative is the continued operation, maintenance, and monitoring of the existing interceptor trenches, French drain, and pumping wells. Shallow groundwater migrates under natural groundwater flow conditions to the existing interceptor trenches and French drain system. Intercepted groundwater is pumped to ASTs for future land application. Further protection against exposure to impacted groundwater will be accomplished by the establishment of Site-wide LURs which will prevent consumption of contaminated groundwater. No additional cost is anticipated beyond the continued operation of groundwater system.

#### 6.1.3.5.2 Area A - Sandstone Hill Shallow Groundwater

Ponds used for the storage of concentrated ammonium nitrate water formerly existed on the west half of Area A in the approximate location of the existing 6,000,000-gallon AST (formerly used to store UAN; currently used to store land application water). Before the early 1970's, the area immediately west of the existing AST was the site of several terraced evaporation ponds, referred to as the Concentrate Ponds. The former Concentrate Ponds held process waste streams and storm water runoff from the urea production and ammonium nitrate areas. These ponds were also temporarily used to store UAN, and a smaller pond was used to store neutralizer condensate. The ponds were removed in 1988. Soil beneath these ponds was contaminated and subsurface soil contamination is still present in this area. Soil sample concentrations that exceeded the RSK goal for ammonia plus nitrate cover an area of approximately 11.2 acres at an average depth of 6.2 feet. The calculated volume of impacted surface and subsurface soils in the area is approximately 111,700 cubic yards, based on site characterization data (36,000 cubic yards of surface soils; 75,700 cubic yards of subsurface soil).

Along the north side of Sandstone Hill, two shallow groundwater interceptor trenches with sumps intercept shallow groundwater migrating from the northeast side of Sandstone Hill and the production areas on the east flank of Sandstone Hill. Shallow groundwater also exits the Sandstone Hill through surface seeps, which drain as surface water from the Hill.

KDHE has determined that the preferred remedial alternative is maintaining the existing groundwater interception at the north end of the Site. Groundwater detected in the overburden and shallow bedrock of Area A migrates downgradient toward the north and northeast. However, the existing groundwater containment system of interceptor trenches, French drain, and pumping wells prevents migration into the alluvial aquifer system associated with the floodplain of the Kansas River. The enhancement of the groundwater containment system through installation of the Central Ponds Trench will help control the migration of groundwater seeping from the south side of Sandstone Hill (see Section 6.1.1.2). Further protection against exposure to impacted groundwater will be accomplished by the establishment of Site-wide LURs. No additional cost is anticipated beyond the continued operation of groundwater system.

#### 6.1.3.5.3 Area D – Operations Area

Shallow groundwater was encountered in the overburden and bedrock during the Site Characterization investigation conducted at the Urea and Nitric Acid Plants. Shallow groundwater was not encountered at the Ammonia Plant. Analyses of the shallow groundwater encountered at the Urea Plant and Nitric Acid Plant indicated nitrate and ammonia concentrations above RSK goals. Shallow groundwater within Area D eventually migrates to the north and is intercepted by a French drain system constructed along the northern edge of the Site.

This drain system intercepts shallow groundwater before it reaches the alluvial aquifer beneath the Kansas River floodplain.

The preferred remedial alternative for shallow groundwater in the area was selected based on the following premises:

- Site-wide shallow groundwater flow is toward the north and exits the Site along the north property boundary.

- The existing groundwater interception system is effective in preventing migration of shallow groundwater to the alluvial aquifer beneath the floodplain.

KDHE has determined that the preferred remedial alternative is the continued operation, maintenance, and monitoring of the existing interceptor trenches, French drain, and pumping wells. Shallow groundwater is contained within silty clay sediments and is of limited quantity and quality. The limited quantities of shallow groundwater which eventually migrate under natural flow conditions are captured by the existing interceptor trenches and French drain system. Intercepted groundwater is pumped to an AST pending land application. Further protection against exposure to impacted groundwater will be accomplished by the establishment of Site-wide LURs. No additional cost is anticipated beyond the continued operation of groundwater system.

### 6.1.4 CRS Unit Monitoring and Closure

Since cleanup activities began in the CRS area, chromium concentrations in groundwater have decreased to acceptable levels. The CRS continues to be subject to the Post-Closure Permit pending return of pH conditions in the groundwater to between 6 and 9. The revised Post-Closure monitoring and reporting requirements for the CRS, as approved by KDHE, include semi-annual sampling of all monitoring wells associated with the CRS and the drainage trench discharge. Samples will be analyzed for pH only. Semi-annual data submittals will follow each semi-annual event and be complemented with the comprehensive annual report. In addition to the analytical costs, the annual Hazardous Waste Monitoring Fee must also be paid for the duration of the Post-Closure Permit. Costs for the operation of this area have been estimated at $216,000.

## *6.2 REDEVELOPMENT ACTIONS – SURFACE WATER MANAGEMENT*

### 6.2.1 Storm Water Management and NPDES Permit Monitoring Program

Storm water management and monitoring is an important aspect of the overall management of environmental issues at the Site. Storm water exiting the Site is currently discharged through on-site ditches and ponds to the Kansas River. This also includes storm water coming on the Site from the south, including runoff from Highway K-10 as well as from land south of Highway K-10.

The only area of the Site where storm water has been shown to be impacted significantly by nitrogen compounds is in Area A (Sandstone Hill) at the north end of the Site. Nitrogen-impacted surface soils and nitrogen-impacted groundwater that appears at the surface as seeps in Area A continue to impact storm water. Storm water data from March 2006 through December 2007 indicates nitrate-nitrogen concentrations ranged from 11 mg/l to 248 mg/L, with an average concentration of 115 mg/L. This range depends on the specific area of runoff, frequency, intensity, and duration of the event, and the path the runoff follows.

The major components of the proposed storm water management system are the desludging of the East and West Effluent Ponds, and the construction of a new storm water drainage ditch, berm, weir structure, and detention basin, using a pump to facilitate drainage from the basin. Once desludged, the East and West Effluent Ponds will be combined into the new detention basin.

It will be necessary to continue to manage and monitor storm water discharge from the Site until the East and West Effluent Ponds are desludged and the new storm water drainage ditch is constructed and placed into operation as discussed in Section 6.2.2.2 of this document. Because these activities are considered to be associated with future redevelopment of the Site, it has been assumed that they will not be completed for a period of at least five years to allow for a Site redevelopment plan to be prepared and evaluated against the conceptual storm water management structure and design. Therefore, storm water monitoring and NPDES permit monitoring as outlined in the Storm Water Management Plan (SMP) submitted to KDHE in 2006 will be required for a period of approximately eight years. This monitoring consists of sampling storm water runoff during storm events and the analysis of the samples for ammonia-nitrogen and nitrate-nitrogen. The purpose of the sampling and analysis is to determine the impact to storm water from specific areas of the Site and to monitor the effectiveness of interim remedial actions taken.

Storm water will continue to be discharged to the Kansas River through the NPDES-permitted outfall. Storm water with concentrations of nitrogen compounds above NPDES limits, primarily from Area A, will be segregated and collected in the Overflow Pond for future use in the land application program after the new storm water drainage ditch and detention basin are constructed and the NPDES permit is no longer in place. Once the new storm water drainage ditch and detention basin are constructed and, as a result of the segregation of impacted storm water for use in the land application program, storm water monitoring should no longer be required.

### 6.2.2 Surface Water Management Infrastructure

The desludging of the East and West Effluent Ponds and the construction of the new storm water drainage ditch are not anticipated to occur until a redevelopment plan for the Site has been prepared. The intent is to allow evaluation of the storm water management requirements for the redevelopment against the conceptual designs of the new storm water drainage ditch and detention basin to ensure that the structure is sufficient to meet the needs of the redevelopment. However, if a redevelopment plan has not been prepared within five years, these activities will be completed and funded from the Administrative Trust.

#### *6.2.2.1 East and West Effluent Pond Sediments Removal*

To facilitate the construction of the new storm water drainage structure, which will use the East and West Effluent Ponds as a detention basin, the accumulated sediments must be removed from these ponds. Before removing the sediments from the ponds, it will be necessary to remove the standing water in the West Effluent, East Effluent, West Lime, East Lime, and Rundown Ponds. During dewatering activities, storm water runoff from non-impacted areas of the Site as well as runoff coming from areas south of the Site will be directed to the effluent ditch. Storm water runoff from impacted areas of the Site will be directed to the Overflow Pond. Water from the East Lime, West Lime, and Rundown Ponds will continue to be directed to the Overflow Pond as needed until they are closed and capped.

The West Effluent Pond sediments, approximately four feet deep, and the East Effluent Pond sediments, approximately five feet deep, will be removed to contact with the underlying native clay. The upper six inches of the native clay will also be removed. An estimated 43,000 cubic yards and 31,300 cubic yards of material (including six inches of native clay base) will be removed from the West Effluent Pond and East Effluent Pond, respectively, and placed in the consolidation ponds.

After removal, samples of the material remaining in the base of the pond will be collected for analysis of nitrogen compounds (nitrate and ammonia), chromium, and arsenic. Once it has been determined that removal of additional pond base material is not warranted or feasible, the ponds will be restored and become part of the detention basin for the new storm water drainage ditch.

#### *6.2.2.2 Storm Water Management Infrastructure- New Storm Water Drainage Ditch*

As a result of the pond closure activities discussed above, a new method for managing non-impacted storm water runoff through the Site is required. Management of non-impacted storm water runoff will need to be accomplished through the construction of a new storm water drainage structure. The new storm water drainage structure would be an extension of the existing main storm water drainage ditch that runs south to north through the Site.

KDHE has developed preliminary plans for the construction of a drainage ditch, berm, weir structure, and detention basin using a pump to facilitate drainage from the detention basin. The construction of the new storm water drainage structure could begin following the removal of sediments from the West Effluent Pond. Construction of the drainage structure would be performed in conjunction with sediment removal from the East Effluent Pond. The new drainage structure must be completed and operational before the final closure activities of the West Lime, Rundown, and East Lime Ponds are completed as current by-pass ditch will be eliminated as part of those actions.

Upon completion, the non-impacted storm water from areas south of the Site as well as non-impacted storm water runoff from the Site would be directed through the main storm water ditch, which includes the newly constructed storm water drainage structure in the western portion of the former West Effluent Pond. Storm water flowing through the Site would exit the Site with ultimate discharge to the Kansas River.

It is anticipated that construction of the new storm water drainage ditch will not be initiated until it has been determined how the Site will be redeveloped. If a redevelopment plan is not available after a period of five years, KDHE will proceed with the construction of the storm water drainage ditch using Administrative Trust funds. The estimated cost is $687,200, which includes 26 years of operation and maintenance of the pump at $6,000 per year for 30 years.

## *6.3 Secondary Remedial Actions*

At the direction of KDHE, the primary remedial actions discussed in Section 6.1 will be completed using the limited Remediation Trust funds, and activities associated with Storm Water Management will be addressed within the limitations of the Administrative Trust funding. However, other remedial activities have been identified as needed to enhance and expedite the remediation of the Site. KDHE has prioritized the order of implementation of remedies recommended for the Site based on the limitations of the Trust funding. The secondary remedial actions discussed here will be required by KDHE and will be completed either through any remaining funding from the Remediation and/or Administrative Trusts, through financial assurances obtained by the purchaser of the Site, and/or through funds generated by redevelopment of areas of the Site.

### 6.3.1 Area A – UAN Storage Area (Sandstone Hill) Soils

Soils in this area with concentrations of ammonia plus nitrate above RSK goals encompass approximately 11.2 acres at an average depth of 6.2 feet. The depth of impact above the RSK goal across the area ranges from 3.5 to 11.5 feet below grade. Remediation of both surface and subsurface soils containing nitrate or ammonia concentrations above RSK goals is considered in order to mitigate impact to shallow groundwater in the overburden and bedrock and mitigate impact to surface water exiting the Site.

The proposed remedial alternatives for soils were based on the following premises:

- Surface soils may represent a health risk and a risk to degradation of surface water and groundwater.

- Subsurface soils may represent a health risk and a risk to degradation of groundwater.

- Shallow groundwater in bedrock and overburden units eventually migrates northward and exits the Site along the north boundary, where it is captured by the existing groundwater control system.

KDHE has determined that the preferred remedial alternative is limited excavation of surface soils with nitrate plus ammonia concentrations greater than 1,000 mg/kg. This remedy is the least costly option, aside from taking no additional action, and was selected based on anticipated benefits to the Site, including:

- Storm water runoff from Sandstone Hill, the area of highest storm water impact on the Site, will be improved.

- Sufficient capacity is available in Area B ponds for the limited quantity of soil, making on-site disposal possible, whereas full excavation of all impacted soils would make on-site disposal problematic.

- Limited excavation can be backfilled with on-site borrow materials, reducing costs of remediation.

- Soil removal can be easily implemented and does not require further engineering design or study.

Reduction of surface nitrogen concentrations by this method is expected to be immediate. Subsurface reductions in nitrogen will occur by long-term infiltration of water and migration of nitrogen compounds through groundwater seeps. Appropriate LURs would be placed on this area of the Site. Estimated cost is $281,550 based on 13,500 cubic yards of soil excavated over 4.2 acres.

### 6.3.2 Central Ponds Soils

During the interim measures performed in May and June 2006, sediments impacted by nitrogen compounds were removed from the area of the Central Ponds and placed in the East Lime Pond. The Central Ponds were then removed and the area backfilled and graded to allow drainage.

Since completion of the interim measures, the surface soils in the area of the former Central Ponds have been impacted by nitrogen compounds from groundwater that surfaces along the southern portion of Sandstone Hill from storm water runoff also originating from the Sandstone Hill. Impacts to the surface soils in this area are evidenced by crystallized residue from evaporated seep water on the ground surface. Sampling of the seeping groundwater indicated concentrations of ammonia at 2,400 mg/L and nitrate at 4,500 mg/L.

As part of the primary remedial actions, an interceptor trench will be installed immediately upgradient of the former Central Ponds to capture the seeping groundwater and direct it to the land application program. Following the installation of the interceptor trench, the surface soils in the area of the former Central Ponds will be excavated and transported to the Area B ponds for disposal. Approximately 2,500 cubic yards of soil are anticipated to be removed from approximately 0.5 acres to a depth of three feet to improve the storm water runoff quality. Following excavation the area will be backfilled, graded, and seeded with vegetation. The area will fall under the Site-wide LURs. Because of the small volume of soil estimated to be involved, this was the only remedial alternative evaluated. The estimated cost to complete this remedial alternative is $52,800.

### 6.3.3 Dam Pond Sediments

Surface soil samples were collected from the drainage rills and from the perimeter of the Bag Warehouse during the Site Characterization investigation. No unusually high concentrations of nitrate or ammonia were observed at that time. However, sediments in the pond have been impacted by nitrate and ammonia in storm water runoff from Sandstone Hill. Concentrations of ammonia-nitrogen and nitrate-nitrite nitrogen were detected up to 826 mg/kg and 283 mg/kg, respectively. The sediments have been removed from the pond and placed outside the dam.

Because of the small volume of sediments estimated to be involved, only one remedial alternative was evaluated. KDHE has determined that excavating the sediments within the footprint of the pond (estimated to be approximately 90 feet by 50 feet) to an approximate depth of two feet and transported to the Area B ponds for disposal is an acceptable remedial alternative. An estimated 350 cubic yards of sediment will be removed. LURs will be needed on the area of the Dam Pond to protect the pond from erosion, removal, or bypass.

The Dam Pond serves an important function in protecting the quality of surface water exiting the Site. Therefore, the pond will be left in place and maintained until surface water runoff from Sandstone Hill can be allowed to discharge directly from the Site. It is not anticipated that additional sediment removal actions in the future will be required within the Dam Pond area. As Site conditions are expected to improve over time, future sediments accumulated within the Dam Pond are not anticipated to have significant concentrations of nitrate and ammonia. The estimated cost to complete this remedial alternative is $6,000.

### 6.3.4 Krehbiel and West Ponds

As a result of the implementation of the RAP strategies to minimize storm water contacting impacted surface soils, the quality of storm water currently routed through the West Pond and Krehbiel Pond will improve. When it is no longer necessary to contain this water for use in the land application program, the storm water can be directed to the main effluent ditch. Monitoring of the storm water currently routed through these two ponds will be performed to determine when quality of the storm water is acceptable for direct discharge.

Once the quality of storm water runoff is acceptable for direct discharge, the sump and piping installed in the West Pond will be removed and the existing dike between the West Pond and Krehbiel Pond will be removed. The sump and pump located in Krehbiel Pond will also be removed. In order to direct the water flowing through these two ponds to the main effluent ditch, the existing overflow structure located at the west end of Krehbiel Pond will be used.

The base of both ponds will be graded to direct storm water flow to the overflow structure at the west end of Krehbiel Pond. Material from the removed dike between the two ponds will be used to facilitate grading. As impacted sediments were previously removed from these two ponds, it is not anticipated that additional sediment removal will be performed. The estimated cost for directing storm water flow through West Pond and Krehbiel Pond to direct discharge to the main effluent ditch is $30,000.

### 6.3.5 Area B Ponds

Interim remedial measures have been performed in Krehbiel Pond, West Pond, and the Overflow Pond as previously discussed in Section 4 of this document. This section addresses remedial measures for the remaining primary ponds.

Based on Site Characterization activities described in Section 3 of this document, nitrate and ammonia were detected in sediments accumulated in these ponds with concentrations of ammonia as high as 23,700 mg/kg and nitrate concentrations as high as 10,900 mg/kg. Of the metals analyzed, only arsenic was detected above non-residential RSK goals at one location in the Area B pond sediments.

These sediments and, potentially, the upper portion of the native clay pond bases immediately underlying the sediments were identified as a primary source area of nitrogen compounds. Addressing these impacted materials would be required before closure of the ponds could be accomplished and to assist in the long-term mitigation of impacts to groundwater from the nitrogen compounds leaching from the material. A total of approximately 245,000 cubic yards of contaminated sediment are estimated to be present in the ponds.

KDHE has determined that the preferred remedial alternative is removal of sediments from the West Extension, West Effluent, and East Effluent Ponds; consolidation in the West Lime, Rundown, and East Lime Ponds; and capping with an 18-inch soil cover and seeded with deep-rooted vegetation. The estimated cost is $1,912,500.

#### *6.3.5.1 Sediment Stabilization*

During the sediment removal activities performed in the Overflow Pond as discussed in Section 4.2.2 of this document, samples of the lime sludge and sediments in the West Lime, Rundown, and East Lime Ponds were collected for one-dimensional consolidation testing to determine the estimated rate and amount of settlement that could occur when the material was loaded with the sediments removed from the West Extension, West Effluent, and East Effluent Ponds. The results of the testing indicate the existing lime sludge would undergo substantial consolidation and settlement upon loading with the sediments, cap, and cover.

KDHE has determined that the preferred remedial alternative is no stabilization of the sediment in the West Lime, Rundown, and East Lime Ponds, which will result in maintenance of the cap/cover over a thirty-year period. Major maintenance events will be performed the first two years to restore the grade as a result of the natural settlement of these materials. Minor maintenance will be performed for the following eight years, and general maintenance will be performed for the remaining 20 years. This provides for cap maintenance from the final closure of the ponds for a period of 30 years. Cap maintenance activities will be scheduled in the late fall of each year to provide adequate time for vegetation to become established. Total cost is estimated at $826,000.

LURs would be required to limit the type of construction on top of the ponds without the performance of a geotechnical analysis and, as necessary, material augmentation by the developer. If the geotechnical analysis indicates sufficient support for building structures, then slab-on-grade construction will be allowed. No subsurface excavation will be allowed.

### 6.3.6 Area A Soils

Soils impacted with nitrogen compounds are present in the Northeast Production Area. No action with LURs was the preferred remedial option for these soils. However, as this area has good redevelopment potential, an allowance has been made for the management of impacted soils that may be encountered during the installation of subsurface utilities in this area. An estimated 5,000 cubic yards of impacted soil have been included in the allowance, which includes excavation of the impacted soil with transportation to the northern ponds for disposal. Backfill is not included as it is assumed backfilling will already be included with the redevelopment activity. The estimated cost associated with the excavation and transportation of 5,000 cubic yards of impacted soil to the northern ponds is $46,750.

### 6.3.7 Area D Soils

Soils impacted with nitrogen compounds are present in the vicinity of Original Landfill and the #2 Urea Plant. No action with LURs was the preferred remedial option for these soils. However, as this area has good redevelopment potential, an allowance has been made for the management of impacted soils that may be encountered during the installation of subsurface utilities in this area. An estimated 10,000 cubic yards of impacted soil have been included in the allowance, which includes excavation of the impacted soil with transportation to the northern ponds for disposal. Backfill is not included as it is assumed backfilling will already be included with the redevelopment activity. The estimated cost associated with the excavation and transportation of 10,000 cubic yards of impacted soil to the northern ponds is $93,500.

### 6.3.8 Production Well Plugging

During the operational period of the Site, seven production water wells, located east of the Site, were used to provide process water to the Site. These seven wells are currently not in use. It is anticipated that these wells will be sold with the Site or will be sold to another third party. However, in the event these wells are not sold, they will need to be properly plugged and abandoned. The estimated cost associated with the proper plugging and abandonment of these seven wells is $36,400.

## 7.0 SUMMARY

KDHE's proposed remedy for the former Farmland Industries Nitrogen Plant Site consists of the following elements:

- Continued operation of the groundwater containment system;
- Addition of a new groundwater recovery well as a supplement to the existing groundwater containment system;
- Construction of a groundwater interceptor trench near the Central Ponds area;
- Installation of a sump to capture fertilizer-contaminated water in the Dam Pond for land application;
- Ongoing monitoring of groundwater on- and off-site to ensure the effectiveness of the combined groundwater containment systems;
- Reclamation of fertilizer-contaminated groundwater and surface water through land application;
- Ongoing maintenance of current surface cover in certain areas of the Site to protect surface water and groundwater quality;
- Ongoing compliance with the Post-Closure Care requirements for the closed Chrome Reduction System unit;
- Desludging of the East and West Effluent Ponds to allow the eventual reconfiguration of clean storm water drainage through the Site until storm water can be routed through the Site without becoming contaminated;
- Ongoing monitoring of surface water quality for the National Pollutant Discharge Elimination System permit and the Storm Water Management Plan;
- Limited excavation of fertilizer-contaminated soil on the Sandstone Hill and in the Central Ponds area;
- Excavation of fertilizer-contaminated sediments from the West Extension, West Effluent, East Effluent, and Dam Ponds, and consolidation and capping of those sediments in the West Lime, Rundown, and East Lime Ponds;
- Contingency removal of fertilizer-contaminated soil areas in the Northeast Production Area and the #2 Urea Plant area to facilitate Site redevelopment;
- Clean-out of the Imhoff tank, flushing of the sewer/pump station, and plugging of sewer lines;
- Contingency plugging of facility production wells if not re-used; and,
- Application of various land use restrictions across the Site to prevent exposures and ensure proper management of contaminated water, sediments, and soil.

In summary, the proposal includes a combination of specific cleanup actions in portions of the Site along with use controls to prevent exposure that, with time, will attain the identified Remedial Action Objectives for the project. In addition, the proposed list of activities will provide overall protection of human health and the environment while balancing costs within the limitations of the remediation and administrative trust funds for the Site. KDHE anticipates the proposed elements will be implemented incrementally over time due to the financial limitations of the Trust and the absence of a viable responsible party following the bankruptcy dissolution of Farmland Industries. KDHE encourages the sale and redevelopment of the Site, and KDHE will consider alternative Site management and cleanup approaches proposed by any prospective purchaser, subject to KDHE's review and approval.

## 8.0 COMMUNITY INVOLVEMENT

KDHE has encouraged public input and comment throughout the process. On October 26, 2009, KDHE issued a news release *in the Lawrence Journal World* announcing the availability of the draft CAD and the public comment period offered from October 26 to November 25, 2009. The notice included information for the public meeting held on November 9, 2009, where the public was given additional opportunity to ask questions and provide comments on the draft CAD. All comments that were received by KDHE prior to the end of the public comment period, either verbally or in writing, are addressed by KDHE in the Response to Comments Summary Section of the Final Corrective Action Decision.

## 9.0 DOCUMENTATION OF MINOR CHANGES

Two written comment letters containing 26 specific comments were received by KDHE during the public comment period. In response to the comments received, KDHE has amended the draft CAD document as specified in Section 10.0

## 10.0 RESPONSE TO COMMENTS SUMMARY

The purpose of this section is to review and provide responses to comments made by private citizens and other interested parties during the public comment period for the Draft CAD. Two comment letters were received, one from the City of Lawrence and the other from The Capitana Group. Comments and KDHE's responses are included below.

***Comment 1*:** *Section 1, page 2, paragraph three, second sentence. The sentence says the Consent Agreement governing the Site was* "between FI Kansas Remediation Trust and KDHE." *While the FI Kansas Remediation Trust may be bound by the Consent Decree, the Consent Decree was actually entered into before the Farmland bankruptcy and was therefore between Farmland Industries and KDHE.*

**KDHE Response:** KDHE agrees with this comment. The CAD has been revised.

***Comment 2:*** *Section 2.3, page 5. In the last paragraph of this section the CAD refers to the future use goal for the Site as* "use as an industrial/commercial property." *As KDHE is aware, a redevelopment plan has been prepared and approved by the City for this Site. The City believes that the approved goal for future use of the Site may be more accurately described as* "use as an industrial/**employment center** property."

**KDHE Response:** KDHE did not take into account redevelopment plans that were in progress during the preparation of a CAD. Reference to future industrial/commercial use is the appropriate zoning term and would include use of the property as an industrial/employment center. No change to the CAD is required.

***Comment 3:*** *Section 6.0.2, page 26. In order to maintain flexibility for potential future transactions and maximize the potential for full remediation of the property and appropriate redevelopment, the CAD should not be drafted in such a way that it might be misinterpreted as imposing any additional restrictions on use of Trust funds beyond those contained in the Trust document itself and as allowed by past approved trust expenditures. Based on this concern, the sentence which currently reads* "Redevelopment Actions – to be implemented in coordination with future Site redevelopment plans or if the property is not sold within a reasonable timeframe by funding from the Administrative Trust." *Should be revised to read* "Redevelopment Actions -- to be implemented in coordination with future Site redevelopment plans **and/or by funding from the Administrative Trust.**"

**KDHE Response:** The KDHE concurs. The CAD has been revised.

***Comment 4:*** *Section 6.0.3, page 26. In order to maintain flexibility for potential future transactions and maximize the potential for full remediation of the property and appropriate redevelopment, the first sentence of this section should be revised to read:* "Secondary Remedial Actions – to be implemented based on available funding in the Remediation and Administrative Trusts **and/or** by a prospective purchaser."

**KDHE Response:** The KDHE concurs. The CAD has been revised.

***Comment 5:*** *In order to maintain flexibility for potential future transactions and maximize the potential for full remediation of the property and appropriate redevelopment, the sentence which currently reads* "The secondary remedial actions discussed here will be required by KDHE and will be completed either through any remaining funds from the Remediation or Administrative Trusts, through financial assurances obtained by the purchaser of the Site, and/or through funds generated by redevelopment of areas of the Site." *Should be revised to read* "The secondary remedial actions discussed here will be required by KDHE and will be completed either through any remaining funds from the Remediation **and/or** Administrative Trusts, through financial assurances obtained by the purchaser of the Site, and/or through fund generated by redevelopment of areas of the Site."

**KDHE Response:** The KDHE concurs. The CAD has been revised.

***Comment 6:*** *CAD Section 2.3 Site History:* "In 2004 following approval of Farmland Industries' Plan of Reorganization by the Bankruptcy Court and concurrence from KDHE, the FI Kansas Remediation Trust (Trust) was formed and funded with approximately $7.0 million (initial remediation fund) to address the remaining environmental impairments at the Site. In 2006 the Trust was funded with approximately $7.8 million (initial administrative fund) to facilitate the sale and manage the administrative activities of the Site." *While this statement is factually accurate, it gives the reader no information regarding the current funding levels of the Trust available for CAD implementation. Because the CAD purports to evaluate and ultimately select a remedy based upon, inter alia, restricted funding, it would be helpful for the reader to have the most current remediation fund and administrative fund balances in order to make an informed decision concerning the appropriateness of the selected remedy.*

**KDHE Response:** While preferred remedial alternatives were indeed influenced by the fact that limited funding is available, KDHE desired to emphasize the limited nature rather than re-iterate actual funding levels of the Trust, which are dynamic due to market conditions and expenditures from the Trust. No change to the CAD is required.

***Comment 7:*** *Additionally, this statement does not provide the reader any context by which to understand the funding restrictions referenced elsewhere in the CAD. Capitana respectfully suggests that this section be revised to include a more complete discussion of the prohibited uses of the remediation and administrative funds as set forth in Sections 5.1 and 5.2 of the FI Kansas Remediation Trust Agreement ("Trust Agreement"), as well as the commingling prohibitions set forth in Section 6.5 of the Trust Agreement.*

**KDHE Response:** KDHE invited comments on the preferred remedy presented in the draft CAD; therefore, this comment is considered irrelevant as it does not pertain to the remedy.

***Comment 8:*** *Finally, Capitana strongly suggests that the Trust Agreement be appended to, and made a part of the CAD by reference and incorporation as though fully set forth therein. By reason of KDHE's own participation, approval and consent, as well as the subsequent entry as an order of the Federal Bankruptcy Court, the Trust Agreement supersedes certain of KDHE's traditional regulatory and enforcement powers respecting the Site. As such, the CAD becomes* *illusory where it references the Trust Agreement, or the implications thereof, without providing the reader the opportunity to evaluate the merits of said reference or implication by the express terms of the Trust Agreement.*

**KDHE Response:** KDHE invited comments on the preferred remedy presented in the draft CAD; therefore, this comment is considered irrelevant as it does not pertain to the remedy.

***Comment 9:*** *CAD Section 2.3 – Site History:* "The Trust, through SELS Administrative Services, LLC as Trustee, manages the environmental and administrative functions of the Site. The Trust retained Shaw Environmental and Infrastructure, Inc. (Shaw), to help manage the mandated compliance and cleanup of the Site in close cooperation with and under the supervision of KDHE and the United States Environmental Protection Agency (EPA). KDHE is the primary beneficiary for the Trust." *Without a more comprehensive explanation, or full incorporation of the Trust Agreement, this statement is at best misleading to the reader and at worst factually inaccurate. By way of example only, this statement does not accurately reflect the express terms of the Trust Agreement with respect to: a) Article II – Declaration of Trust; b) Article III – Purpose of Trust; c) Article VI – Trust Administration; and Article VII – Express Powers of Trustee. Additionally, the statement alludes to, yet gives no information concerning KDHE's co-beneficiary, Capitana. Use of the phrase "primary beneficiary" without reference to the Trust Agreement may mislead the reader with respect to the relative rights and interests of the co-beneficiaries.*

**KDHE Response:** KDHE invited comments on the preferred remedy presented in the draft CAD; therefore, this comment is considered irrelevant as it does not pertain to the remedy.

***Comment 10:*** *CAD Section 2.3 – Site History:* "The goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property and will prevent unacceptable human exposure to residual site contamination under that use scenario. The elements of the proposed remedy are listed in prioritized manner due to the current uncertainties surrounding future ownership, use, and configuration of the redeveloped property." *No explanation is given with respect to the "current uncertainties surrounding future ownership, use, and configuration of the redeveloped property." As such, the reader has no ability to evaluate the "current uncertainties" as they may or may not impact remedy selection. Additionally, the statement contradicts itself by characterizing "anticipated future use as an industrial/commercial property", yet thereafter referencing future use as one of the several "current uncertainties". Capitana respectfully suggests that this statement be modified to more clearly express the Site's "anticipated future use as an industrial/commercial property".*

**KDHE Response:** KDHE concurs. The CAD has been revised.

***Comment 11:*** *CAD Section 5.1 – Contaminants of Concern:* "KDHE has developed chemical-specific and site-specific cleanup goals called Risk-Based Standards for Kansas (RSK) using guidance, methods, and directives from EPA and other technical sources. These RSK goals are concentrations of individual contaminants that have been calculated using generic physical and chemical parameters and generalized exposure assumptions that are considered protective of human health and the environment. RSK goals have been developed for contaminants in soil and in groundwater and for both residential and non-residential exposure settings. In general, RSK goals for a residential exposure setting are lower (more protective) than those for a non-residential exposure. RSK goals serve as useful benchmarks for comparison to site contaminant concentrations to evaluate, on a screening level, whether site contamination may pose a potential risk to human health if exposure occurs. More information on the development and use of KDHE's RSK manual is available at http://www.kdheks.gov/remedial/rsk_manual_page.htm. Comparison to KDHE's RSK goals and other values developed by KDHE and EPA were used to evaluate those constituents that pose a potential risk to human health, the environment, or natural resources at and near the Site.

. . .

Other constituents, including fuel and solvent compounds, other metals, and PCBs have been detected at the Site. None of these contaminants were detected above KDHE's non-residential RSK goals. Total chromium results exceeded the residential RSK goal in some sediment samples in the Northern Ponds Area, but the results were below the non-residential RSK goal. Chromium was not detected at significant concentrations in other portions of the Site in groundwater, soil, or surface or storm water. Mercury was detected at a concentration above the residential RSK goal but below the non-residential RSK goal in only one sample in the Northern Ponds Area and is not considered further in this CAD. Other compounds detected during the 2005 Site Characterization investigation were present at concentrations below their respective residential RSK goals. Because they are detected infrequently and at concentrations below the non-residential RSK goals, they are not further discussed in this CAD. Detailed information concerning historical contaminant detections at the Site is included in various investigation documents, particularly the 2005 Site Characterization Report."

*In light of the fact that,* "the goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property," *repeated references to residential RSK goals is confusing. References to residential RSK goals are inapposite to the CAD's stated goal of achieving cleanup supportive of non-residential uses. Capitana respectfully suggests that KDHE modify this statement to reconcile the Site's supported use remediation goal with the appropriate RSK goals so that the reader can more effectively evaluate the proposed remedy.*

**KDHE Response:** Remedies are compared to residential RSK as a baseline for site cleanup. EUCs are a component of the proposed remedy to restrict residential use and allow for consideration of alternate cleanup standards such as the industrial use standards. No change to the CAD is required.

***Comment 12:*** *CAD Section 5.3.1 – Groundwater Pathway:* "Current and future residential use of groundwater on Site is not considered due to the availability of a municipal water supply. Nevertheless, consumption of nitrate-contaminated groundwater on many portions of the Site would pose an unacceptable risk."

*Capitana respectfully suggests that this statement be modified to remove the reference to "residential use of groundwater" in favor of the term "consumption." Capitana is unaware of any intended residential future use, and as such this statement tends to confuse the reader that the Site may support residential use in the future.*

**KDHE Response:** KDHE agrees that "residential use of groundwater" should be removed and replaced with the term "consumption". In both residential and non-residential scenarios, nitrate-contaminated groundwater poses an unacceptable risk. In addition, migration off-site is a concern that can best be resolved by cleanup to Public Water Supply Standards since downgradient off-site wells are being used for human consumption. The CAD has been modified.

***Comment 13:*** *CAD Section 5.3.2 – Soil and Sediment Pathway*: "Arsenic was found in surface and subsurface soils and sediments throughout the Site at concentrations that exceed the residential RSK goal but are generally below the non-residential RSK goal. Two sediment samples in the East Lime Pond in the Northern Ponds Area exceeded the non-residential RSK goal. While some arsenic in soil and sediment at the Site is likely naturally-occurring, some may also be attributable to former Farmland operations. Residential exposure to arsenic in soil and sediment at the Site could pose a potential human health risk. Chromium was detected in sediments in some of the northern ponds at concentrations that exceed the residential RSK goal but are below the non-residential RSK goal. Residential exposure to chromium in sediment at the Site could pose a potential human health risk." *In light of the fact that,* "the goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property," *repeated references to residential RSK goals is confusing. References to residential RSK goals are inapposite to the CAD's stated goal of achieving cleanup supportive of non-residential uses. Capitana respectfully suggests that KDHE modify this statement to reconcile the Site's supported use remediation goal with the appropriate RSK goals so that the reader can more effectively evaluate the proposed remedy.*

**KDHE Response:** Remedies are compared to residential RSK as a baseline for site cleanup. EUCs are a component of the proposed remedy to restrict residential use and allow for consideration of alternate cleanup standards such as the industrial use standards. No change to the CAD is required.

***Comment 14:*** *CAD Section 5.4.1 – Groundwater Cleanup Goals:* "The EPA has established a drinking water standard of 10.0 mg/L nitrate as nitrogen in public drinking water supplies, which KDHE has adopted as the groundwater cleanup goal. The EPA has not established a drinking water standard for ammonia." *Capitana respectfully suggests that KDHE modify this statement to explain why it is adopting the Federal drinking water standard for the groundwater cleanup goal at a Site where,* "current and future residential use of groundwater on Site is not considered." *See, CAD Section 5.3.1. Additionally, the reader is given no information to consider whether or not beneficial use groundwater underlies the Site. By way of example only, would the groundwater underlying the Site be potable but for the presence of the contaminants of concern? Conversely, is the groundwater underlying the Site non-potable as a result of TDS or some other non-contaminant of concern issue?*

**KDHE Response:** KDHE's policy is to restore contaminated groundwater to its most beneficial use. This is also a component of K.A. R. 28-71-11(l)(m) and (n). The statement "current and future residential use of groundwater on Site is not considered" is in the context of evaluating potential human exposure pathways. While a municipal water supply is available at the Site, allowing contamination to remain would be a violation of the policy and associated regulations. BER Policy #BER-RS-045 "Considerations for Groundwater Use and Applying RSK Standards to Contaminated Groundwater" addresses the application of these standards. No change to the CAD is required.

**Comment 15:** CAD Section 5.4.2 – Soil and Sediment Cleanup Goals: "RSK soil levels for nitrate and ammonia were developed to be protective of soil contamination migrating to groundwater. RSK goals for total nitrate plus ammonia are:

<u>Surface Soil</u>

- 85 mg/kg in the upper eight inches of soil in areas where no vegetation is present
- 200 mg/kg in the upper 24 inches of soil where vegetation is present

<u>Subsurface Soil</u>

- 40 mg/kg below eight inches of soil in areas where no vegetation is present
- 40 mg/kg below 24 inches of soil where vegetation is present

Previous investigations have identified numerous areas of surface and subsurface soil and sediment contaminated by nitrate and ammonia at concentrations above RSK goals."

*This statement is made without giving the reader any information regarding KDHE's consideration, if any, of the previously stated Site specific cleanup goal. Without any such guidance, the statement appears to be a perfunctory recitation of the RSK Manual's goals which contravenes RSK Manual by its own terms. "The soil cleanup guidelines provided below were developed by KDHE/BER in consultation with Kansas State University agronomy experts to provide* ***<u>non-site</u>*** *specific soil cleanup goals that are generally protective of ground water and capable of sustaining vegetative growth." Risk-Based Standards for Kansas, RSK Manual – 4th Edition (June 2007), Page 14 (****<u>emphasis added</u>****). Capitana respectfully suggests that this statement be modified to include a discussion of KDHE's deliberative process, presumptively evaluating site specific soil cleanup goals, which ultimately resulted in the use of the same* ***<u>non-site</u>*** *specific soil cleanup goals set forth in the RSK Manual.*

**KDHE Response:** The use of non-site specific cleanup goals in the Risk-Based Standards for Kansas (RSK) Manual is a cost-effective approach in that it does not require the performance of costly and time-consuming baseline risk assessments and/or contaminant fate and transport models. These goals are considered protective of human health and the environment, and flexibility is provided through land-use controls. No change to the CAD is required.

***Comment 16:*** *CAD Section 5.4.2 – Soil and Sediment Cleanup Goals:* "The KDHE RSK goals for arsenic in soil are 11 mg/kg for soil in a residential exposure setting and 38 mg/kg for soil in a non-residential exposure setting." *In light of the fact that,* "the goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property," *repeated references to residential RSK goals is confusing. References to residential RSK goals are inapposite to the CAD's stated goal of achieving cleanup supportive of non-residential uses. Capitana respectfully suggests that KDHE modify this statement to reconcile the Site's supported use remediation goal with the appropriate RSK goals so that the reader can more effectively evaluate the proposed remedy.*

**KDHE Response:** Remedies are compared to residential RSK as a baseline for site cleanup. EUCs are a component of the proposed remedy to restrict residential use and allow for consideration of alternate cleanup standards such as the industrial use standards. No change to the CAD is required.

***Comment 17:*** *CAD Section 5.4.2 – Soil and Sediment Cleanup Goals:* "The KDHE RSK goals for total chromium [chromium (III) plus chromium (VI)] in soil are 390 mg/kg for soil in a residential setting and 4000 mg/kg for chromium in a non-residential exposure setting." *In light of the fact that,* "the goal for this Site is to remediate the property to a condition that will allow its anticipated future use as an industrial/commercial property," *repeated references to residential RSK goals is confusing. References to residential RSK goals are inapposite to the CAD's stated goal of achieving cleanup supportive of non-residential uses. Capitana respectfully suggests that KDHE modify this statement to reconcile the Site's supported use remediation goal with the appropriate RSK goals so that the reader can more effectively evaluate the proposed remedy.*

**KDHE Response:** Remedies are compared to residential RSK as a baseline for site cleanup. EUCs are a component of the proposed remedy to restrict residential use and allow for consideration of alternate cleanup standards such as the industrial use standards. No change to the CAD is required.

***Comment 18:*** *CAD Section 6.0 – Summary of Remedial Alternatives and the Preferred Remedial Alternative:*

"2. Redevelopment Actions – to be implemented in coordination with future Site redevelopment plans or, if the property is not sold within a reasonable timeframe, by funding from the Administrative Trust:

a. Modify infrastructures, operations, and maintenance of storm water management systems to meet the needs of future redevelopment plans and maintain current NPDES requirements, as well as those incorporated into future NPDES permits. This includes removal of sludge from the East and West Effluent Ponds so they can be used for future non-contact storm water detention.

3. Secondary Remedial Actions – to be implemented based on available funding in the Remediation and Administrative Trusts or by a prospective purchaser:

a. Excavation and management of impacted soils in select areas of the Site to improve storm water runoff quality;
b. Excavation and management of impacted soils to accommodate future redevelopment or construction;
c. Final closure of the northern ponds, including the Overflow Pond."

*Capitana respectfully suggests that this section of the CAD be revised to eliminate all references to the term "Administrative Trusts". (The use of the term "Administrative Trusts" by KDHE is conclusively demonstrative of the need to append the Trust Agreement in its entirety. The term "Administrative Trusts" appears nowhere in the Trust Agreement. Capitana surmises that this is a reference to the segregated "Administrative Funds" as that term is defined on page 2 of the Trust Agreement.) Assuming, arguendo, KDHE intended to use the phrase "Administrative Funds" in this section of the CAD, Capitana further respectfully suggests that such phrase be* *stricken as well. Again, without the aid of the Trust Agreement, the reader has no context by which to evaluate the proposed remedy. By way of example only, without the Trust Agreement, the reader has no way to consider whether or not the proposed remedy qualifies as an "Administrative Expense" under the Trust Agreement. "The Trustee shall make payments from the Administrative Funds for the sole purpose of paying Administrative Expenses"; and as such the proposed remedy must qualify as an Administrative Expense, since "in no event shall Administrative Funds be used for any other purpose or shall any other funds be used for Administrative Expense." See, Trust Agreement Section 5.2.*

*By this statement KDHE misleads the reader in that there is no "reasonable time" trigger for use of Administrative Funds for remedial activities, improperly implying that KDHE has some apparent ethereal right to access Administrative Funds for remedial activities. By appending the Trust Agreement the reader will be allowed to reach his/her own conclusion regarding the likelihood that KDHE will ever be successful in eviscerating the express restrictions and limitations on the use of Administrative Funds. This gross misstatement of fact precludes 1 The use of the term "Administrative Trusts" by KDHE is conclusively demonstrative of the need to append the Trust Agreement in its entirety. The term "Administrative Trusts" appears nowhere in the Trust Agreement. Capitana surmises that this is a reference to the segregated "Administrative Funds" as that term is defined on page 2 of the Trust Agreement. meaningful public review and comment respecting the CAD, and is likely violative of administrative due process.*

**KDHE Response:** KDHE invited comments on the preferred remedy presented in the draft CAD; therefore, this comment is considered irrelevant as it does not pertain to the remedy.

***Comment 19:*** *CAD Section 6.1 – Preliminary Remedial Actions: This CAD section 6.1, and each of its subsections, purports to provide monetary estimates relative to the various, preferred remedies. The reader, however, is given neither context, nor definition in order to evaluate the reasonableness of the monetary estimates. Capitana respectfully suggests that this Section of the CAD be revised to accurately describe the monetary estimates. By way of example only, do the monetary estimates represent present or future values? If so, what discount rate was applied, and were inflationary assumptions accretive or dilutive? If the time value of money was not considered, KDHE must provide its rationale in this regard so that the reader can evaluate the reasonableness of that atypical approach.*

*Given the repeated references throughout the CAD to limited monetary resources, it is critical that the reader be given a more clear understanding of the remedial costs and the clear understanding of the Trust Agreement's absolute proscription against use of any funds, other than Remediation Funds, for the payment of Environmental Actions. By appending the Trust Agreement, the reader will be able to more comprehensively evaluate the tension between remedial actions and the limited funding available to implement those remedial actions.*

**KDHE Response:** The CAD states that the Remedial Action Plan provides cost estimates to implement the proposed remedies. The RAP provides a detailed breakdown of the activities and costs of each remedial alternative considered at present monetary values in the text, with future values detailed in Figure 8-2 of the RAP. Since this comment does not directly address the technical information provided, no change to the CAD is required.

***Comment 20:*** *CAD Section 6.2 – Redevelopment Actions – Surface Water Management: This CAD section 6.2, and each of its subsections, purports to provide monetary estimates relative to the various, preferred remedies. The reader, however, is given neither context, nor definition in order to evaluate the reasonableness of the monetary estimates. Capitana respectfully suggests that this Section of the CAD be revised to accurately describe the monetary estimates. By way of example only, do the monetary estimates represent present or future values? If so, what discount rate was applied, and were inflationary assumptions accretive or dilutive? If the time value of money was not considered, KDHE must provide its rationale in this regard so that the reader can evaluate the reasonableness of that atypical approach.*

*Given the repeated references throughout the CAD to limited monetary resources, it is critical that the reader be given a more clear understanding of the remedial costs and the clear understanding of the Trust Agreement's absolute proscription against use of any funds, other than Remediation Funds, for the payment of Environmental Actions. By appending the Trust Agreement, the reader will be able to more comprehensively evaluate the tension between remedial actions and the limited funding available to implement those remedial actions.*

**KDHE Response:** The CAD states that the Remedial Action Plan provides cost estimates to implement the proposed remedies. The RAP provides a detailed breakdown of the activities and costs of each remedial alternative considered at present monetary values in the text, with future values detailed in Figure 8-2 of the RAP. Since this comment does not directly address the technical information provided, no change to the CAD is required.

***Comment 21: CAD Section 6.2.1 – Storm Water Management and NPDES Permit Monitoring Program:*** "It will be necessary to continue to manage and monitor storm water discharge from the Site until the East and West Effluent Ponds are desludged and the new storm water drainage ditch is constructed and placed into operation as discussed in Section 6.2.2.2 of this document. Because these activities are considered to be associated with future redevelopment of the Site, it has been assumed that they will not be completed for a period of at least five years to allow for a Site redevelopment plan to be prepared and evaluated against the conceptual storm water management structure and design. Therefore, storm water monitoring and NPDES permit monitoring as outlined in the Storm Water Management Plan (SMP) submitted to KDHE in 2006 will be required for a period of approximately eight years. This monitoring consists of sampling storm water runoff during storm events and the analysis of the samples for ammonia-nitrogen and nitrate-nitrogen. The purpose of the sampling and analysis is to determine the impact to storm water from specific areas of the Site and to monitor the effectiveness of interim remedial actions taken.

Storm water will continue to be discharged to the Kansas River through the NPDES-permitted outfall. Storm water with concentrations of nitrogen compounds above NPDES limits, primarily from Area A, will be segregated and collected in the Overflow Pond for future use in the land application program after the new storm water drainage ditch and detention basin are constructed and the NPDES permit is no longer in place. Once the new storm water drainage ditch and detention basin are constructed and, as a result of the segregation of impacted storm water for use in the land application program, storm water monitoring should no longer be required."

*In light of Comment No. [22], below, this statement is likely moot, and as such confusing to the reader. Capitana respectfully suggest that CAD Section 6.2.1 and 6.2.2 be reversed in sequence. This will clarify for the reader the fact that without the Surface Water Management Infrastructure, Storm Water Management and NPDES Permit Monitoring Program will remain unchanged. Put another way, the Storm Water Management and NPDES Permit Monitoring Program will be modified if, and only if, the Surface Water Management Infrastructure is implemented through use of funds other than Administrative Funds.*

**KDHE Response:** KDHE addresses the surface water and storm water in sequential order and does not agree that reversing the order of CAD Sections 6.2.1 and 6.2.2 will clarify meaning for the reader. No change to the CAD is required.

***Comment 22****: CAD Section 6.2.2 – Surface Water Management Infrastructure:* "The desludging of the East and West Effluent Ponds and the construction of the new storm water drainage ditch are not anticipated to occur until a redevelopment plan for the Site has been prepared. The intent is to allow evaluation of the storm water management requirements for the redevelopment against the conceptual designs of the new storm water drainage ditch and detention basin to ensure that the structure is sufficient to meet the needs of the redevelopment. However, if a redevelopment plan has not been prepared within five years, these activities will be completed and funded from the Administrative Trust."

*Capitana respectfully suggests that this section of the CAD be revised to eliminate all references to the term "Administrative Trusts". Assuming, arguendo, KDHE intended to use the phrase "Administrative Funds" in this section of the CAD, Capitana further respectfully suggests that such phrase be stricken as well. Again, without the aid of the Trust Agreement, the reader has no context by which to evaluate the proposed remedy. By way of example only, without the Trust Agreement, the reader has no way to consider whether or not the proposed remedy qualifies as an "Administrative Expense" under the Trust Agreement. "The Trustee shall make payments from the Administrative Funds for the sole purpose of paying Administrative Expenses"; and as such the proposed remedy must qualify as an Administrative Expense, since "in no event shall Administrative Funds be used for any other purpose or shall any other funds be used for Administrative Expense." See, Trust Agreement Section 5.2.*

*By this statement KDHE misleads the reader in that there is no "reasonable time" trigger for use of Administrative Funds for remedial activates, improperly implying that KDHE has some apparent ethereal right to access Administrative Funds for remedial activities. By appending the Trust Agreement the reader will be allowed to reach his/her own conclusion regarding the likelihood that KDHE will ever be successful in eviscerating the express restrictions and limitations on the use of Administrative Funds. This gross misstatement of fact precludes meaningful public review and comment respecting the CAD, and is likely violative of administrative due process.*

**KDHE Response:** KDHE stated if a redevelopment plan had not been prepared within five years, the activities would commence. Five years was considered a reasonable time frame and is consistent with the RAP developed by the Trustee. Since KDHE invited comments on the preferred remedy presented in the draft CAD, comments regarding the Trust Agreement and Administrative Fund usage are considered irrelevant. No change to the CAD is required.

***Comment 23:*** *CAD Section 6.2.2.1 – East and West Effluent Pond Sediments Removal:* "To facilitate the construction of the new storm water drainage structure, which will use the East and West Effluent Ponds as a detention basin, the accumulated sediments must be removed from these ponds. Before removing the sediments from the ponds, it will be necessary to remove the standing water in the West Effluent, East Effluent, West Lime, East Lime, and Rundown Ponds. During dewatering activities, storm water runoff from non-impacted areas of the Site as well as runoff coming from areas south of the Site will be directed to the effluent ditch. Storm water runoff from impacted areas of the Site will be directed to the Overflow Pond. Water from the East Lime, West Lime, and Rundown Ponds will continue to be directed to the Overflow Pond as needed until they are closed and capped.

The West Effluent Pond sediments, approximately four feet deep, and the East Effluent Pond sediments, approximately five feet deep, will be removed to contact with the underlying native clay. The upper six inches of the native clay will also be removed. An estimated 43,000 cubic yards and 31,300 cubic yards of material (including six inches of native clay base) will be removed from the West Effluent Pond and East Effluent Pond, respectively, and placed in the consolidation ponds.

After removal, samples of the material remaining in the base of the pond will be collected for analysis of nitrogen compounds (nitrate and ammonia), chromium, and arsenic. Once it has been determined that removal of additional pond base material is not warranted or feasible, the ponds will be restored and become part of the detention basin for the new storm water drainage ditch."

*In light of Comment [22], above, this statement is also likely moot, and as such confusing to the reader. Capitana respectfully suggest that all CAD Sections related to "Redevelopment Actions", be prefaced with a qualifying statement indicating the lack of KDHE authority (through KDHE's own ceding of same) to access Administrative Funds for non-Administrative Expenses.*

*Again, without the aid of the Trust Agreement, the reader has no context by which to evaluate the proposed remedy. By way of example only, without the Trust Agreement, the reader has no way to consider whether or not the proposed remedy qualifies as an "Administrative Expense" under the Trust Agreement. "The Trustee shall make payments from the Administrative Funds for the sole purpose of paying Administrative Expenses"; and as such the proposed remedy must qualify as an Administrative Expense, since "in no event shall Administrative Funds be used for any other purpose or shall any other funds be used for Administrative Expense." See, Trust Agreement Section 5.2.*

*By this statement KDHE misleads the reader, improperly implying that KDHE has some apparent ethereal right to access Administrative Funds for remedial activities. By appending the*

*Trust Agreement the reader will be allowed to reach his/her own conclusion regarding the likelihood that KDHE will ever be successful in eviscerating the express restrictions and limitations on the use of Administrative Funds. This gross misstatement of fact precludes meaningful public review and comment respecting the CAD, and is likely violative of administrative due process.*

**KDHE Response:** Since KDHE invited comments on the preferred remedy presented in the draft CAD, comments regarding the Trust Agreement and Administrative Fund usage are considered irrelevant. No change to the CAD is required.

***Comment 24:*** *CAD Section 6.2.2.2 – Storm Water Management Infrastructure – New Storm Water Drainage Ditch:* "As a result of the pond closure activities discussed above, a new method for managing nonimpacted storm water runoff through the Site is required. Management of non-impacted storm water runoff will need be accomplished through the construction of a new storm water drainage structure. The new storm water drainage structure would be an extension of the existing main storm water drainage ditch that runs south to north through the Site.

KDHE has developed preliminary plans for the construction of a drainage ditch, berm, weir structure, and detention basin using a pump to facilitate drainage from the detention basin. The construction of the new storm water drainage structure could begin following the removal of sediments from the West Effluent Pond. Construction of the drainage structure would be performed in conjunction with sediment removal from the East Effluent Pond. The new drainage structure must be completed and operational before the final closure activities of the West Lime, Rundown, and East Lime Ponds are completed as current by-pass ditch will be eliminated as part of those actions.

Upon completion, the non-impacted storm water from areas south of the Site as well as nonimpacted storm water runoff from the Site would be directed through the main storm water ditch, which includes the newly constructed storm water drainage structure in the western portion of the former West Effluent Pond. Storm water flowing through the Site would exit the Site with ultimate discharge to the Kansas River.

It is anticipated that construction of the new storm water drainage ditch will not be initiated until it has been determined how the Site will be redeveloped. If a redevelopment plan is not available after a period of five years, KDHE will proceed with the construction of the storm water drainage ditch using Administrative Trust funds. The estimated cost is $687,200, which includes 26 years of operation and maintenance of the pump at $6,000 per year for 30 years."

*Capitana respectfully suggest that all CAD Sections related to "Redevelopment Actions", be prefaced with a qualifying statement indicating the lack of KDHE authority (through KDHE's own ceding of same) to access Administrative Funds for non-Administrative Expenses.*

*Again, without the aid of the Trust Agreement, the reader has no context by which to evaluate the proposed remedy. By way of example only, without the Trust Agreement, the reader has no way to consider whether or not the proposed remedy qualifies as an "Administrative Expense" under the Trust Agreement. "The Trustee shall make payments from the Administrative Funds for the* *sole purpose of paying Administrative Expenses"; and as such the proposed remedy must qualify as an Administrative Expense, since "in no event shall Administrative Funds be used for any other purpose or shall any other funds be used for Administrative Expense." See, Trust Agreement Section 5.2.*

*By this statement KDHE misleads the reader, improperly implying that KDHE has some apparent ethereal right to access Administrative Funds for remedial activities. By appending the Trust Agreement the reader will be allowed to reach his/her own conclusion regarding the likelihood that KDHE will ever be successful in eviscerating the express restrictions and limitations on the use of Administrative Funds. This gross misstatement of fact precludes meaningful public review and comment respecting the CAD, and is likely violative of administrative due process.*

**KDHE Response:** Since KDHE invited comments on the preferred remedy presented in the draft CAD, comments regarding the Trust Agreement and Administrative Fund usage are considered irrelevant. No change to the CAD is required.

***Comment 25:*** *CAD Section 6.3 – Secondary Remedial Actions: CAD section 6.3, and each of its subsections, purports to provide monetary estimates relative to the various, preferred remedies. The reader, however, is given neither context, nor definition in order to evaluate the reasonableness of the monetary estimates. Capitana respectfully suggests that this Section of the CAD be revised to accurately describe the monetary estimates. By way of example only, do the monetary estimates represent present or future values? If so, what discount rate was applied, and were inflationary assumptions accretive or dilutive? If the time value of money was not considered, KDHE must provide its rationale in this regard so that the reader can evaluate the reasonableness of that atypical approach.*

*Given the repeated references throughout the CAD to limited monetary resources, it is critical that the reader be given a more clear understanding of the remedial costs and the clear understanding of the Trust Agreement's absolute proscription against use of any funds, other than Remediation Funds, for the payment of Environmental Actions. By appending the Trust Agreement, the reader will be able to more comprehensively evaluate the tension between remedial actions and the limited funding available to implement those remedial actions.*

**KDHE Response:** The CAD states that the Remedial Action Plan provides cost estimates to implement the proposed remedies. The RAP provides a detailed breakdown of the activities and costs of each remedial alternative considered at present monetary values in the text, with future values detailed in Figure 8-2 of the RAP. Since this comment does not directly address the technical information provided, no change to the CAD is required.

***Comment 26:*** *CAD Section 6.3 – Secondary Remedial Actions:* "At the direction of KDHE, the primary remedial actions discussed in Section 6.1 will be completed using the limited Remediation Trust funds, and activities associated with Storm Water Management will be addressed within the limitations of the Administrative Trust funding. However, other remedial activities have been identified as needed to enhance and expedite the remediation of the Site. KDHE has prioritized the order of implementation of remedies recommended for the Site based on the limitations of the Trust funding. The secondary remedial actions discussed here will be required by KDHE and will be completed either through any remaining funding from the Remediation or Administrative Trusts, through financial assurances obtained by the purchaser of the Site, and/or through funds generated by redevelopment of areas of the Site."

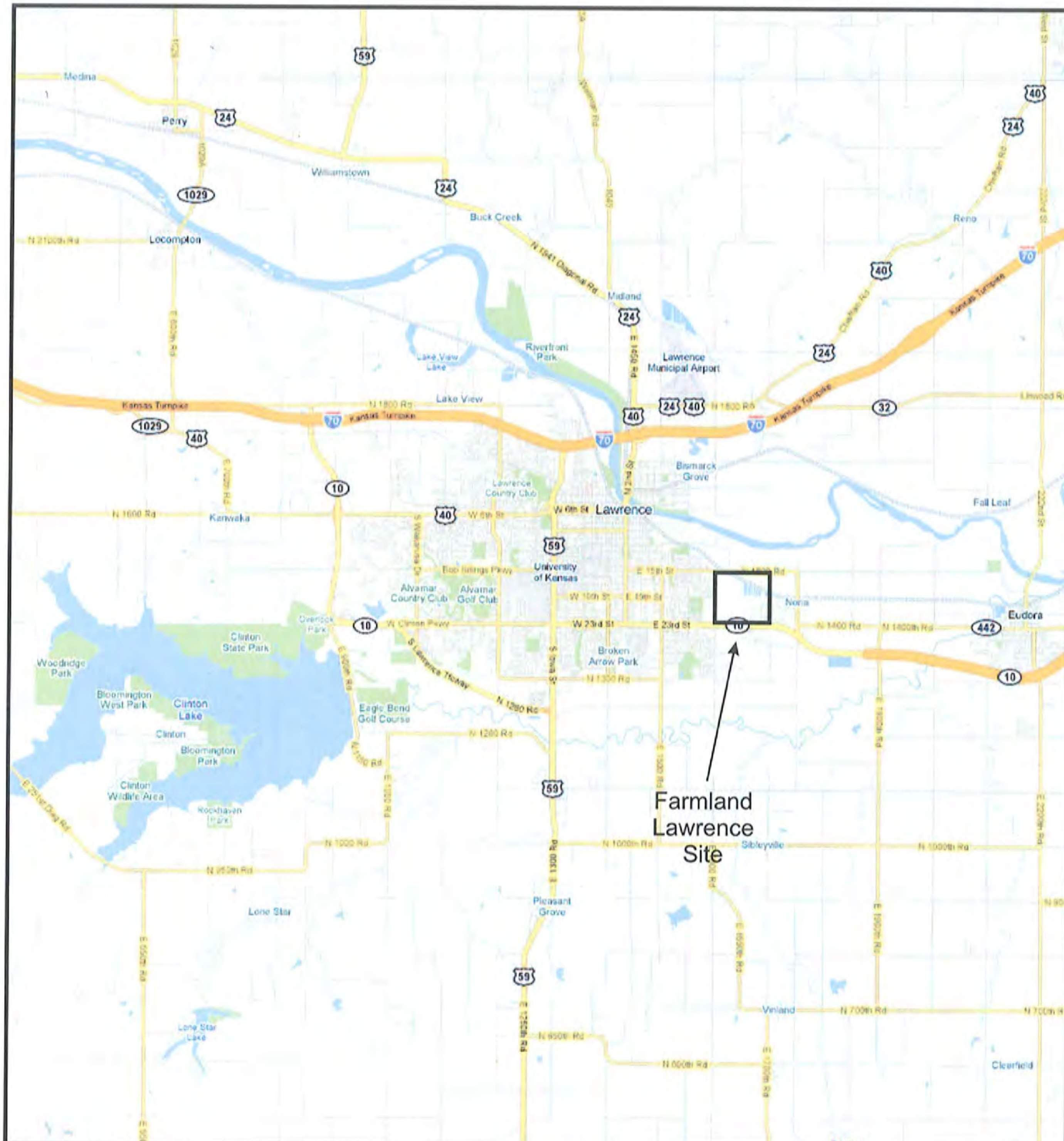
*Capitana respectfully suggest that all CAD Sections related to "Secondary Remedial Actions", be prefaced with a qualifying statement indicating the lack of KDHE authority (through KDHE's own ceding of same) to access Administrative Funds for non-Administrative Expenses, or income generated by the Site which is the sole and exclusive property of co-beneficiary Capitana pursuant to Trust Agreement section 5.3.*

*Again, without the aid of the Trust Agreement, the reader has no context by which to evaluate the proposed remedy. By way of example only, without the Trust Agreement, the reader has no way to consider whether or not the proposed remedy qualifies as an "Administrative Expense" under the Trust Agreement. "The Trustee shall make payments from the Administrative Funds for the sole purpose of paying Administrative Expenses"; and as such the proposed remedy must qualify as an Administrative Expense, since "in no event shall Administrative Funds be used for any other purpose or shall any other funds be used for Administrative Expense." See, Trust Agreement Section 5.2.*

*Additionally, the statement misleads the reader by speciously alleging KDHE's right to access income generated by the Site. KDHE's express relinquishment of any right to Site generated income is set forth in Trust Agreement section 5.3.*

*By this statement KDHE misleads the reader, improperly implying that KDHE has some apparent ethereal right to access Administrative Funds and/or Site generated income for remedial activities. By appending the Trust Agreement the reader will be allowed to reach his/her own conclusion regarding the likelihood that KDHE will ever be successful in eviscerating the express restrictions and limitations on the use of Administrative Funds and ownership of Site generated income. This gross misstatement of fact precludes meaningful public review and comment respecting the CAD, and is likely violative of administrative due process.*

**KDHE Response:** Since KDHE invited comments on the preferred remedy presented in the draft CAD, comments regarding the Trust Agreement and Administrative Fund usage are considered irrelevant. No change to the CAD is required.




Map prepared by KDHE

N

Scale: 0 2 4
Scale in Miles

Douglas County

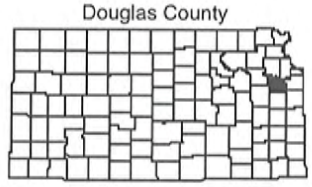
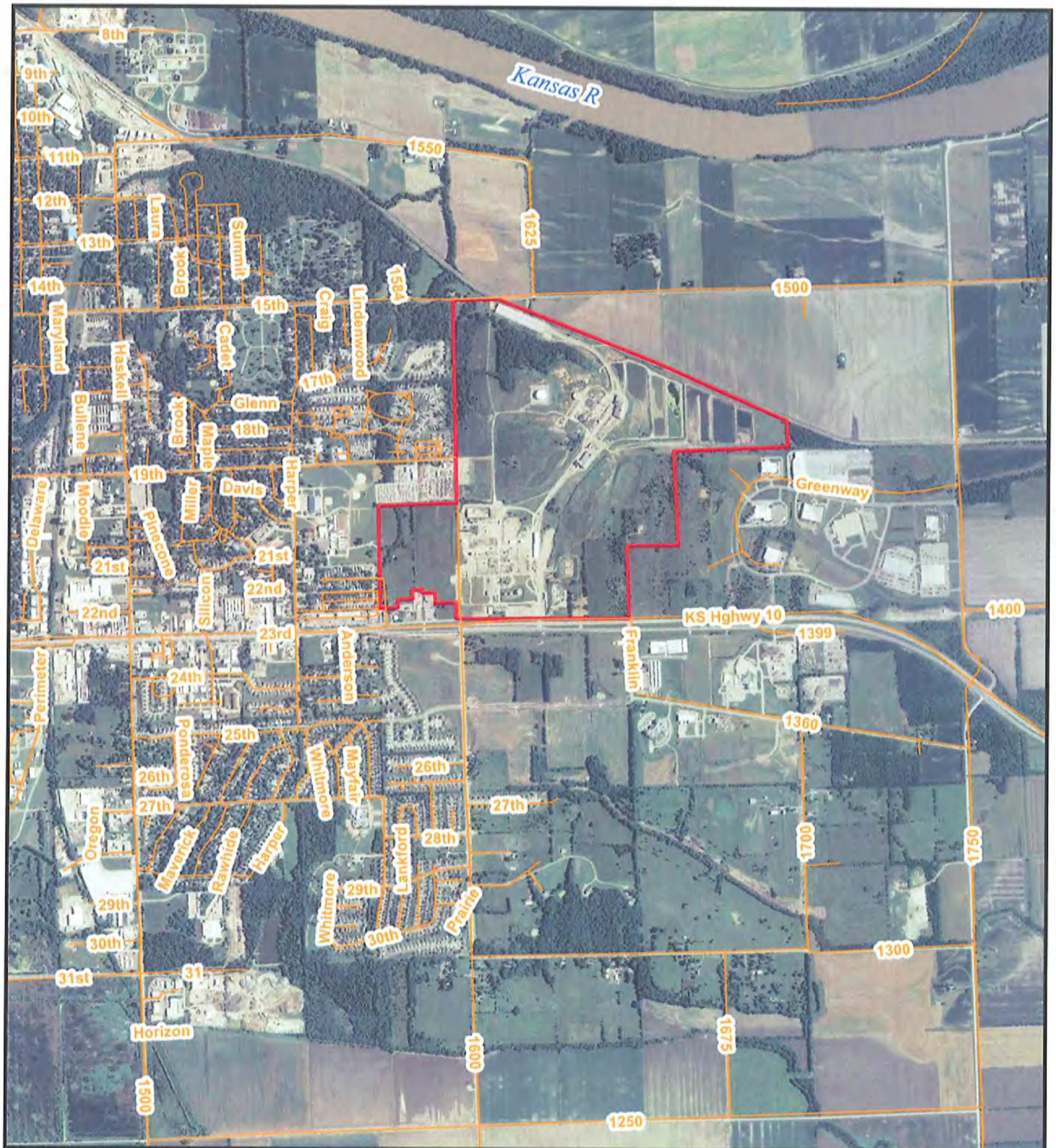


**FIGURE 1**

Site Location Map
Former Farmland Industries
Nitrogen Plant
Lawrence, Kansas

Project Manager: PG Drawn by: PBJ




0 1,000 2,000 4,000 Feet

N

**LEGEND**

Local Roads

Property Boundary

**Figure 2**

Property Boundary Map
Former Farmland Industries
Nitrogen Plant
Lawrence, Kansas

Map Prepared by KDHE

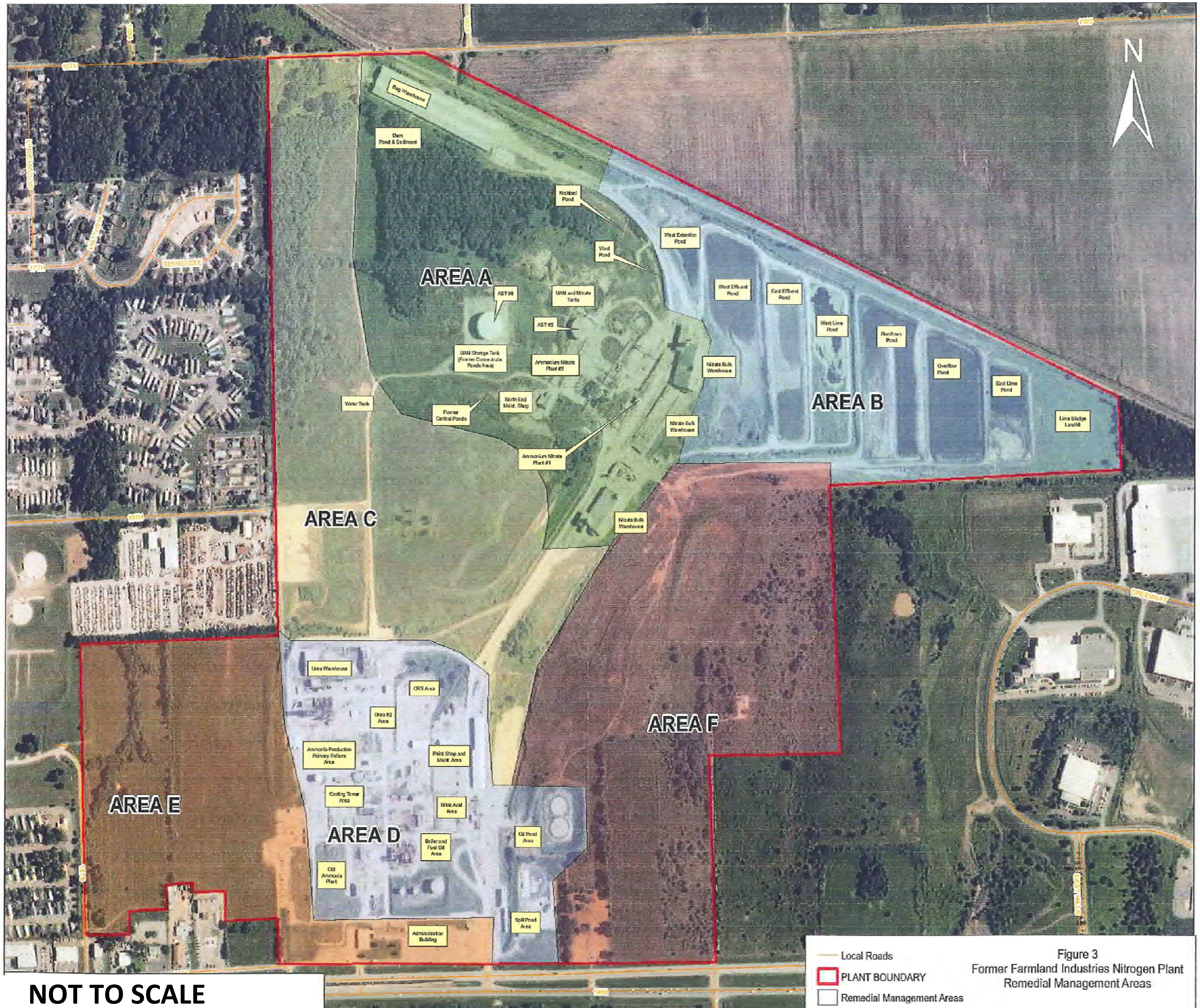
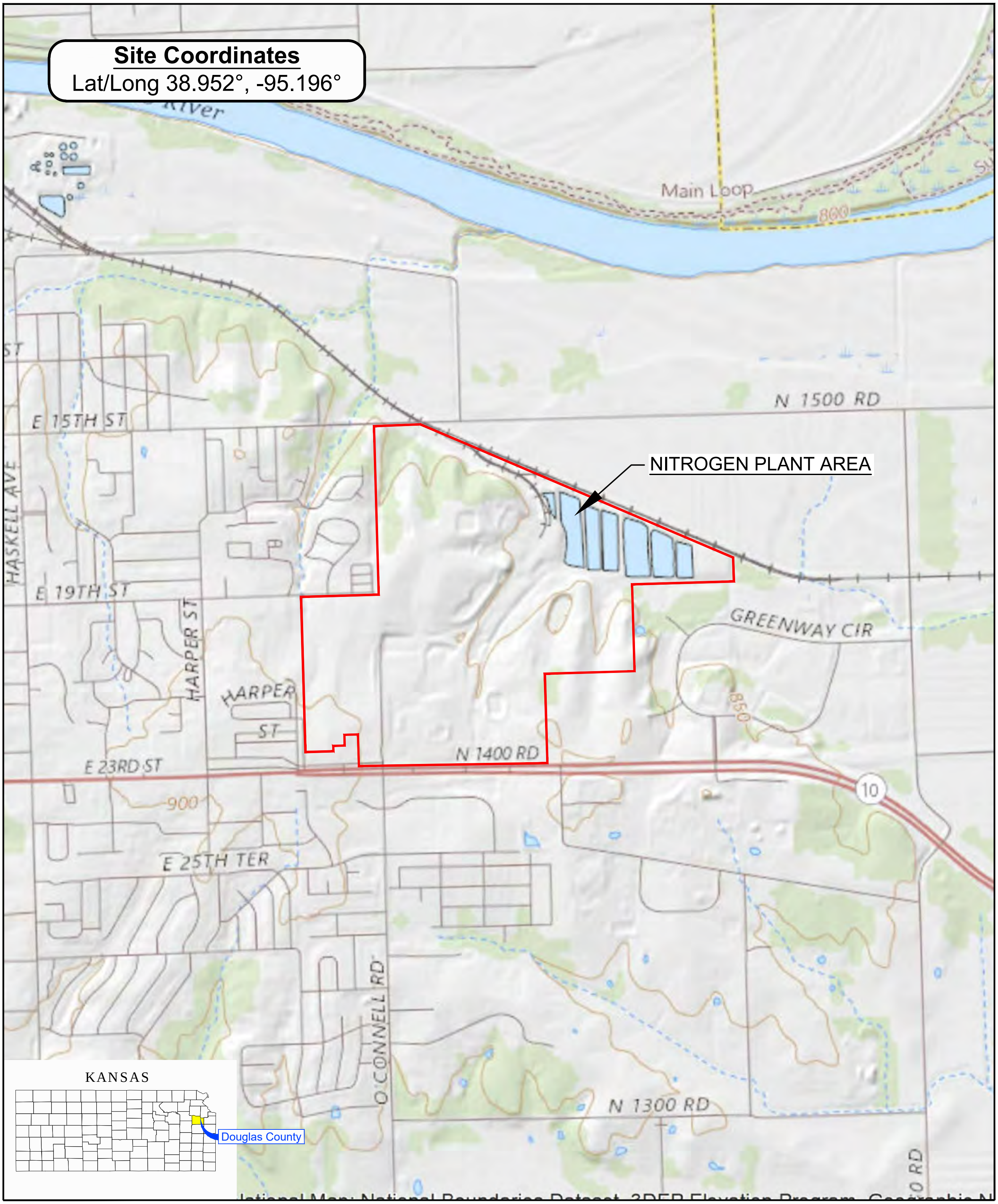



Figure 3
Former Farmland Industries Nitrogen Plant
Remedial Management Areas

# Appendix B
# Select Data Gap Study Report Figures – February 2020




Source: USGS 7.5 MINUTE QUAD "LAWRENCE EAST, KANSAS"

0 1000 2000ft

Coordinate System: STATE PLANE - KANSAS SOUTH

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 RPAD, LAWRENCE, KANSAS

11152783-02

Sep 3, 2019

SITE LOCATION MAP

FIGURE 1

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL002_Topo.dwg


Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 200 400ft

N

LEGEND

- Monitoring Well Location
  - A: Perched
  - B: Alluvial
- Plugged Monitoring Well
- Permitted NPDES Outfall
- Groundwater Recovery Well
- Interceptor Trench Sump
- Private Domestic Well
- Soil Boring Location
- Property Boundary

GHD

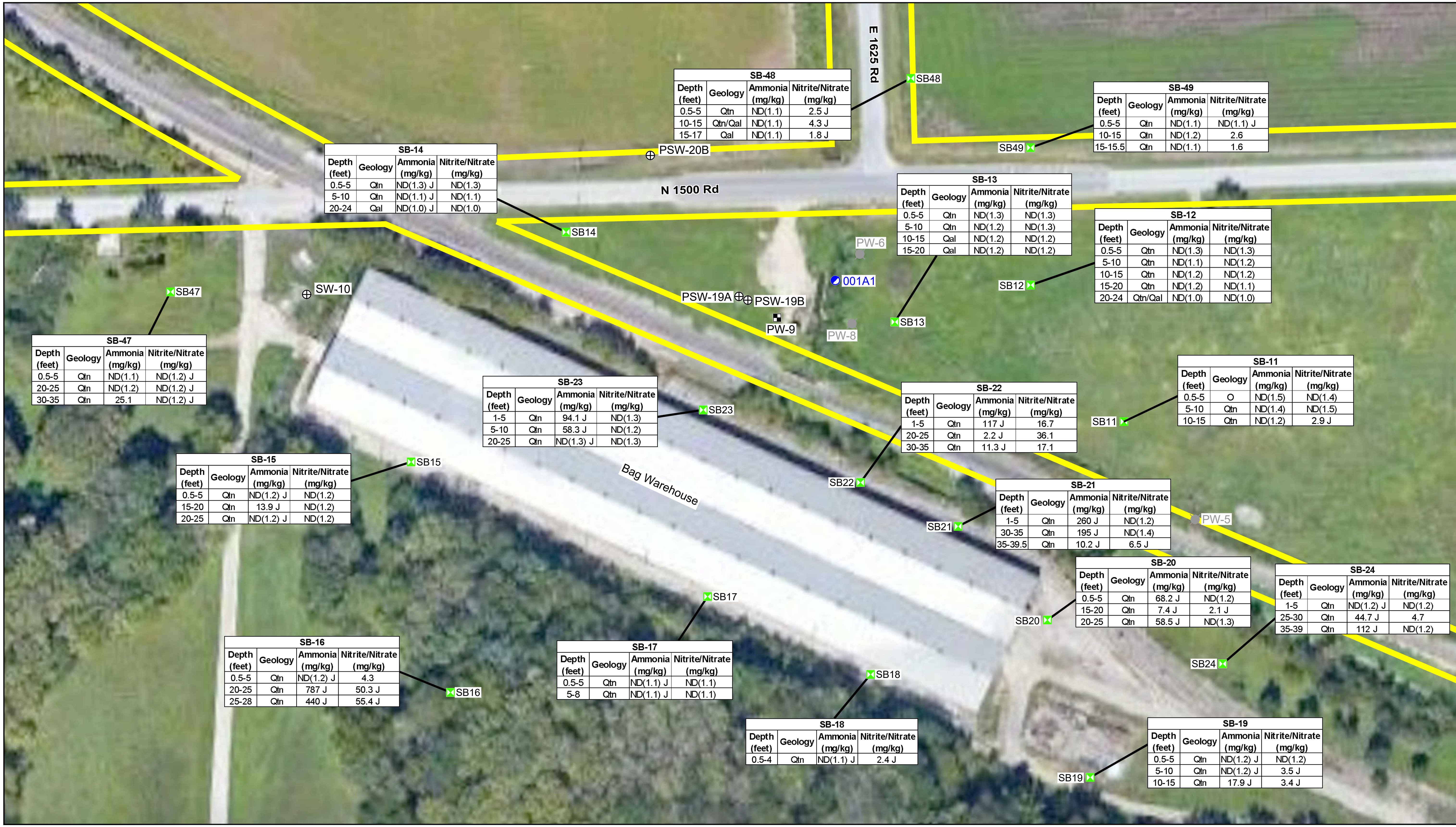
FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

SITE LAYOUT - DGS SOIL BORING LOCATIONS

11152783-02
Mar 13, 2020

FIGURE 2

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg




**SB-48**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.1) | 2.5 J |
| 10-15 | Qtn/Qal | ND(1.1) | 4.3 J |
| 15-17 | Qal | ND(1.1) | 1.8 J |

**SB-49**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.1) | ND(1.1) J |
| 10-15 | Qtn | ND(1.2) | 2.6 |
| 15-15.5 | Qtn | ND(1.1) | 1.6 |

**SB-14**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.3) J | ND(1.3) |
| 5-10 | Qtn | ND(1.1) J | ND(1.1) |
| 20-24 | Qal | ND(1.0) J | ND(1.0) |

**SB-13**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.3) | ND(1.3) |
| 5-10 | Qtn | ND(1.2) | ND(1.3) |
| 10-15 | Qal | ND(1.2) | ND(1.2) |
| 15-20 | Qal | ND(1.2) | ND(1.2) |

**SB-12**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.3) | ND(1.3) |
| 5-10 | Qtn | ND(1.1) | ND(1.2) |
| 10-15 | Qtn | ND(1.2) | ND(1.2) |
| 15-20 | Qtn | ND(1.2) | ND(1.1) |
| 20-24 | Qtn/Qal | ND(1.0) | ND(1.0) |

**SB-47**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.1) | ND(1.2) J |
| 20-25 | Qtn | ND(1.2) | ND(1.2) J |
| 30-35 | Qtn | 25.1 | ND(1.2) J |

**SB-23**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 1-5 | Qtn | 94.1 J | ND(1.3) |
| 5-10 | Qtn | 58.3 J | ND(1.2) |
| 20-25 | Qtn | ND(1.3) J | ND(1.3) |

**SB-22**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 1-5 | Qtn | 117 J | 16.7 |
| 20-25 | Qtn | 2.2 J | 36.1 |
| 30-35 | Qtn | 11.3 J | 17.1 |

**SB-11**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | O | ND(1.5) | ND(1.4) |
| 5-10 | Qtn | ND(1.4) | ND(1.5) |
| 10-15 | Qtn | ND(1.2) | 2.9 J |

**SB-15**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.2) J | ND(1.2) |
| 15-20 | Qtn | 13.9 J | ND(1.2) |
| 20-25 | Qtn | ND(1.2) J | ND(1.2) |

**SB-21**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 1-5 | Qtn | 260 J | ND(1.2) |
| 30-35 | Qtn | 195 J | ND(1.4) |
| 35-39.5 | Qtn | 10.2 J | 6.5 J |

**SB-20**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | 68.2 J | ND(1.2) |
| 15-20 | Qtn | 7.4 J | 2.1 J |
| 20-25 | Qtn | 58.5 J | ND(1.3) |

**SB-24**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 1-5 | Qtn | ND(1.2) J | ND(1.2) |
| 25-30 | Qtn | 44.7 J | 4.7 |
| 35-39 | Qtn | 112 J | ND(1.2) |

**SB-16**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.2) J | 4.3 |
| 20-25 | Qtn | 787 J | 50.3 J |
| 25-28 | Qtn | 440 J | 55.4 J |

**SB-17**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.1) J | ND(1.1) |
| 5-8 | Qtn | ND(1.1) J | ND(1.1) |

**SB-18**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-4 | Qtn | ND(1.1) J | 2.4 J |

**SB-19**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.2) J | ND(1.2) |
| 5-10 | Qtn | ND(1.2) J | 3.5 J |
| 10-15 | Qtn | 17.9 J | 3.4 J |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 50 100ft

LEGEND

- Monitoring Well Location
  A: Perched
  B: Alluvial
- Plugged Monitoring Well
- Permitted NPDES Outfall
- Groundwater Recovery Well
- Soil Boring Location
- Property Boundary
- ND Not Detected
- J Indicates Estimated Concentration

GEOLOGY DESCRIPTION LEGEND

Qtn - NEWMAN DEPOSITS
Qal - KANSAS ALLUVIAL DEPOSITS

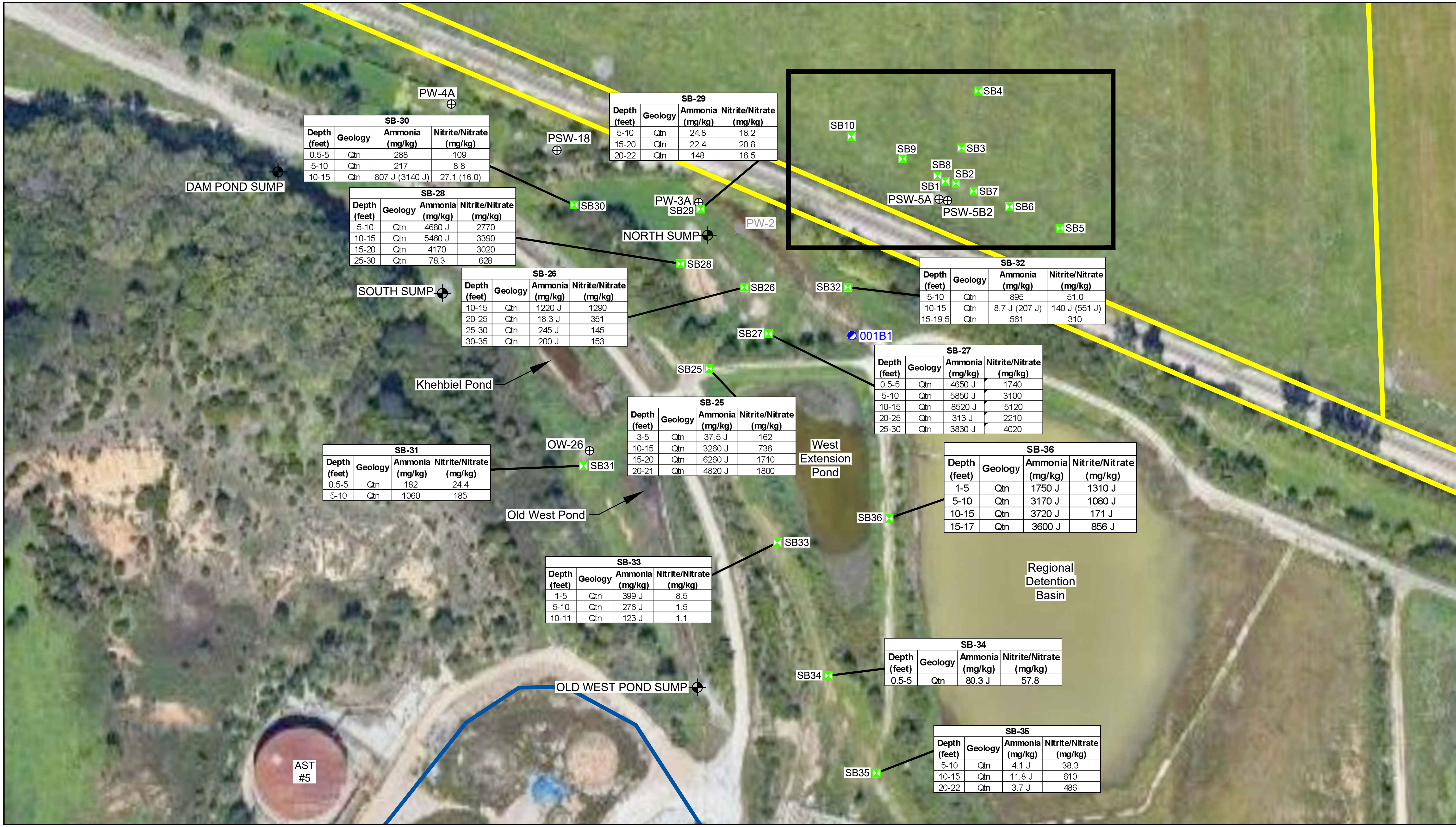
FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02
Sep 3, 2019

SOIL SAMPLING RESULTS - BAG WAREHOUSE

FIGURE 3

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg




| SB-30 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 0.5-5 | Qtn | 288 | 109 |
| 5-10 | Qtn | 217 | 8.8 |
| 10-15 | Qtn | 807 J (3140 J) | 27.1 (16.0) |

| SB-29 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 5-10 | Qtn | 24.8 | 18.2 |
| 15-20 | Qtn | 22.4 | 20.8 |
| 20-22 | Qtn | 148 | 16.5 |

| SB-28 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 5-10 | Qtn | 4680 J | 2770 |
| 10-15 | Qtn | 5460 J | 3390 |
| 15-20 | Qtn | 4170 | 3020 |
| 25-30 | Qtn | 78.3 | 628 |

| SB-26 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 10-15 | Qtn | 1220 J | 1290 |
| 20-25 | Qtn | 18.3 J | 351 |
| 25-30 | Qtn | 245 J | 145 |
| 30-35 | Qtn | 200 J | 153 |

| SB-32 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 5-10 | Qtn | 895 | 51.0 |
| 10-15 | Qtn | 8.7 J (207 J) | 140 J (551 J) |
| 15-19.5 | Qtn | 561 | 310 |

| SB-27 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 0.5-5 | Qtn | 4650 J | 1740 |
| 5-10 | Qtn | 5850 J | 3100 |
| 10-15 | Qtn | 8520 J | 5120 |
| 20-25 | Qtn | 313 J | 2210 |
| 25-30 | Qtn | 3830 J | 4020 |

| SB-25 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 3-5 | Qtn | 37.5 J | 162 |
| 10-15 | Qtn | 3260 J | 736 |
| 15-20 | Qtn | 6260 J | 1710 |
| 20-21 | Qtn | 4820 J | 1800 |

| SB-31 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 0.5-5 | Qtn | 182 | 24.4 |
| 5-10 | Qtn | 1060 | 185 |

| SB-36 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 1-5 | Qtn | 1750 J | 1310 J |
| 5-10 | Qtn | 3170 J | 1080 J |
| 10-15 | Qtn | 3720 J | 171 J |
| 15-17 | Qtn | 3600 J | 856 J |

| SB-33 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 1-5 | Qtn | 399 J | 8.5 |
| 5-10 | Qtn | 276 J | 1.5 |
| 10-11 | Qtn | 123 J | 1.1 |

| SB-34 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 0.5-5 | Qtn | 80.3 J | 57.8 |

| SB-35 | | | |
|---|---|---|---|
| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
| 5-10 | Qtn | 4.1 J | 38.3 |
| 10-15 | Qtn | 11.8 J | 610 |
| 20-22 | Qtn | 3.7 J | 486 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 40 120ft

N

LEGEND

- Monitoring Well Location
  A: Perched
  B: Alluvial
- Plugged Monitoring Well
- Permitted NPDES Outfall
- Interceptor Trench Sump
- Soil Boring Location
- Property Boundary
- J Indicates Estimated Concentration

GEOLOGY DESCRIPTION LEGEND

Qtn - NEWMAN DEPOSITS
Qal - KANSAS ALLUVIAL DEPOSITS

GHD

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02
Mar 13, 2020

SOIL SAMPLING RESULTS - WEST EXTENSION POND

FIGURE 4

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg


**SB-40**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 5-8 | Qtn | 7.0 J | 2.0 J |
| 14-15 | Qtn | 158 | 170 |
| 17-20 | Qtn | 563 J | 3.8 |
| 20-25 | Qtn | 232 J | 36.2 |
| 25-26 | Qtn | 218 J | 34.3 |
| 26-28 | Qtn | 193 J | 124 |

**SB-39**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | ND(1.2) J | 1.8 J |
| 5-7 | Qtn | 2.9 J | ND(1.5) J |
| 15-20 | Qtn | 411 J | 376 J |
| 20-24 | Qtn | 896 J | 280 J |
| 24-25 | Qtn | 680 J | 240 J |

**SB-41**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0-5 | Qtn | ND(1.3) J | 4.5 |
| 5-10 | Qtn | 77.8 J | 805 |
| 10-15 | Qtn | 1650 J | 931 |
| 17-20 | Qtn | 3130 J | 1030 |

**SB-38**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 5-9 | Qtn | ND(1.5) J | 20.2 J |
| 10-14 | Qtn | 766 J | 768 J |
| 16-20 | Qtn | 141 J | 351 J |
| 23.5-25 | Qtn | ND(1.3) J | 505 J |
| 33-35 | Qtn | 58.3 J | 1.5 J |
| 40-41 | Qtn | 151 J | 16.7 J |

**SB-42**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0-5 | Qtn | ND(1.3) | 10.9 |
| 5-10 | Qtn | 24.9 J | 282 |
| 10-15 | Qtn | 475 J | 885 |
| 20-25 | Qtn | 3650 J | 1450 |
| 25-30 | Qtn | 5860 J | 2600 |
| 31-33 | Qtn | 3390 J | 1890 |

**SB-45**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | 5.4 J | 3.0 J |
| 5-10 | Qtn | 2.9 J | 59.2 J |
| 17.5-20 | Qtn | 33.7 J | ND(1.2) J |
| 20-25 | Qtn | 43.3 | 21.3 J |
| 28-29 | Qtn | 6.7 | 37.5 J |

**SB-46**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | 1150 | 519 J |
| 5-6 | Qtn | 346 | 335 J |
| 15-19 | Lime | 9.9 | 35.6 J |
| 19-20 | Qtn | 36.2 | 4.8 J |
| 20-25 | Qtn | ND(1.1) | 72.8 J |
| 38-40 | Qtn | 10.5 | 34.6 J |

**SB-37**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 2-5 | Qtn | ND(1.2) | 3.0 J |
| 5-8 | Qtn | 4.1 J | 2.0 J |
| 10-13 | Qtn | 20.1 J | ND(1.3) J |
| 13-15 | Qtn | 147 J | 11.8 J |

**SB-44**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | 38.3 J | 107 |
| 5-10 | Qtn | 475 J | 2640 |
| 20-25 | Qtn | 193 J | 102 J |
| 26-27 | Qtn | 37.1 J | 85.9 J |

**SB-43**

| Depth (feet) | Geology | Ammonia (mg/kg) | Nitrite/Nitrate (mg/kg) |
|---|---|---|---|
| 0.5-5 | Qtn | 2030 J | 1390 |
| 5-9 | Qtn | 1570 J | 822 |
| 16.5-20 | Qtn | 56.3 J | 38.7 |
| 35-40 | Qtn | 19.9 J | 54.1 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 200 400ft

N

LEGEND

- Monitoring Well Location
  - A: Perched
  - B: Alluvial
- Plugged Monitoring Well
- Groundwater Recovery Well
- Interceptor Trench Sump
- Soil Boring Location
- Property Boundary
- ND Not Detected
- J Indicates Estimated Concentration

GEOLOGY DESCRIPTION LEGEND

Qtn - NEWMAN DEPOSITS
Qal - KANSAS ALLUVIAL DEPOSITS

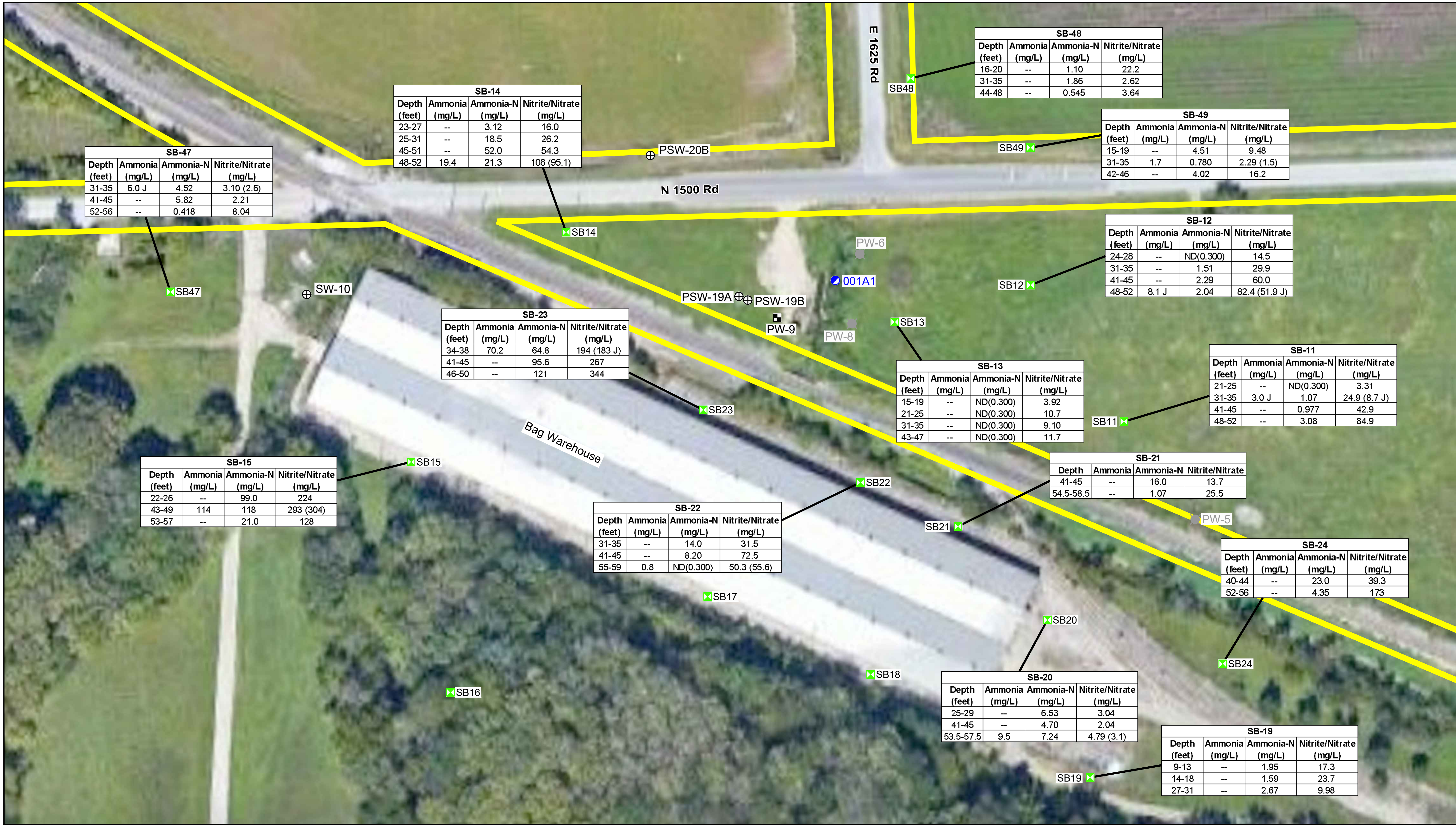
FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

SOIL SAMPLING RESULTS - EAST AND WEST LIME PONDS

11152783-02
Sep 3, 2019

FIGURE 5

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg




**SB-48**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 16-20 | -- | 1.10 | 22.2 |
| 31-35 | -- | 1.86 | 2.62 |
| 44-48 | -- | 0.545 | 3.64 |

**SB-14**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 23-27 | -- | 3.12 | 16.0 |
| 25-31 | -- | 18.5 | 26.2 |
| 45-51 | -- | 52.0 | 54.3 |
| 48-52 | 19.4 | 21.3 | 108 (95.1) |

**SB-49**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 15-19 | -- | 4.51 | 9.48 |
| 31-35 | 1.7 | 0.780 | 2.29 (1.5) |
| 42-46 | -- | 4.02 | 16.2 |

**SB-47**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 31-35 | 6.0 J | 4.52 | 3.10 (2.6) |
| 41-45 | -- | 5.82 | 2.21 |
| 52-56 | -- | 0.418 | 8.04 |

**SB-12**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 24-28 | -- | ND(0.300) | 14.5 |
| 31-35 | -- | 1.51 | 29.9 |
| 41-45 | -- | 2.29 | 60.0 |
| 48-52 | 8.1 J | 2.04 | 82.4 (51.9 J) |

**SB-23**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 34-38 | 70.2 | 64.8 | 194 (183 J) |
| 41-45 | -- | 95.6 | 267 |
| 46-50 | -- | 121 | 344 |

**SB-11**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 21-25 | -- | ND(0.300) | 3.31 |
| 31-35 | 3.0 J | 1.07 | 24.9 (8.7 J) |
| 41-45 | -- | 0.977 | 42.9 |
| 48-52 | -- | 3.08 | 84.9 |

**SB-13**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 15-19 | -- | ND(0.300) | 3.92 |
| 21-25 | -- | ND(0.300) | 10.7 |
| 31-35 | -- | ND(0.300) | 9.10 |
| 43-47 | -- | ND(0.300) | 11.7 |

**SB-21**

| Depth | Ammonia | Ammonia-N | Nitrite/Nitrate |
|---|---|---|---|
| 41-45 | -- | 16.0 | 13.7 |
| 54.5-58.5 | -- | 1.07 | 25.5 |

**SB-15**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 22-26 | -- | 99.0 | 224 |
| 43-49 | 114 | 118 | 293 (304) |
| 53-57 | -- | 21.0 | 128 |

**SB-22**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 31-35 | -- | 14.0 | 31.5 |
| 41-45 | -- | 8.20 | 72.5 |
| 55-59 | 0.8 | ND(0.300) | 50.3 (55.6) |

**SB-24**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 40-44 | -- | 23.0 | 39.3 |
| 52-56 | -- | 4.35 | 173 |

**SB-20**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 25-29 | -- | 6.53 | 3.04 |
| 41-45 | -- | 4.70 | 2.04 |
| 53.5-57.5 | 9.5 | 7.24 | 4.79 (3.1) |

**SB-19**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 9-13 | -- | 1.95 | 17.3 |
| 14-18 | -- | 1.59 | 23.7 |
| 27-31 | -- | 2.67 | 9.98 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 50 100ft

LEGEND

- Monitoring Well Location
  - A: Perched
  - B: Alluvial
- Plugged Monitoring Well
- Permitted NPDES Outfall
- Groundwater Recovery Well
- Soil Boring Location
- Property Boundary
- ND Not Detected
- J Indicates Estimated Concentration

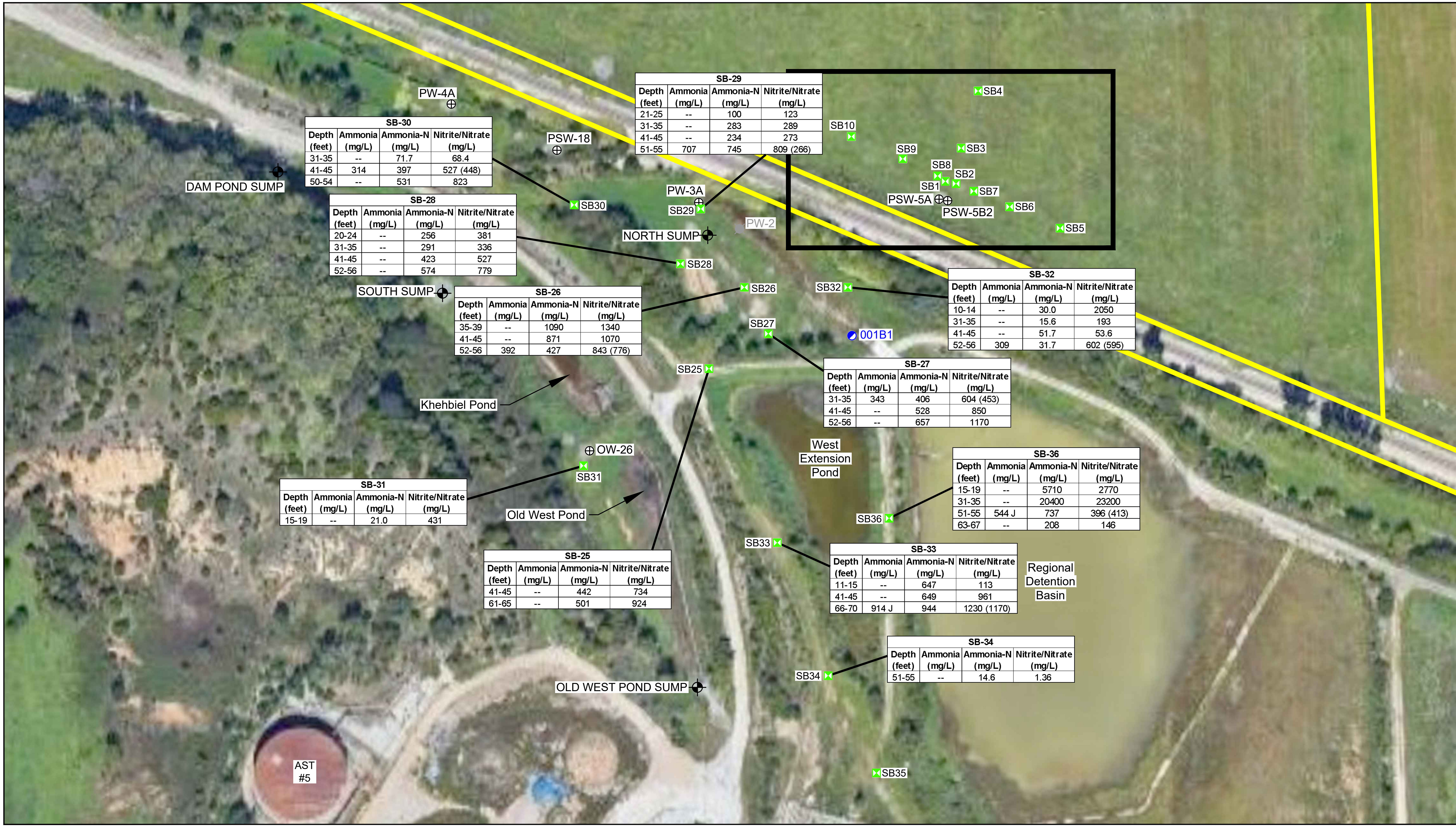
FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02
Sep 3, 2019

GROUNDWATER SAMPLING RESULTS - BAG WAREHOUSE

FIGURE 6

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg




**SB-29**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 21-25 | -- | 100 | 123 |
| 31-35 | -- | 283 | 289 |
| 41-45 | -- | 234 | 273 |
| 51-55 | 707 | 745 | 809 (266) |

**SB-30**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 31-35 | -- | 71.7 | 68.4 |
| 41-45 | 314 | 397 | 527 (448) |
| 50-54 | -- | 531 | 823 |

**SB-28**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 20-24 | -- | 256 | 381 |
| 31-35 | -- | 291 | 336 |
| 41-45 | -- | 423 | 527 |
| 52-56 | -- | 574 | 779 |

**SB-26**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 35-39 | -- | 1090 | 1340 |
| 41-45 | -- | 871 | 1070 |
| 52-56 | 392 | 427 | 843 (776) |

**SB-32**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 10-14 | -- | 30.0 | 2050 |
| 31-35 | -- | 15.6 | 193 |
| 41-45 | -- | 51.7 | 53.6 |
| 52-56 | 309 | 31.7 | 602 (595) |

**SB-27**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 31-35 | 343 | 406 | 604 (453) |
| 41-45 | -- | 528 | 850 |
| 52-56 | -- | 657 | 1170 |

**SB-36**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 15-19 | -- | 5710 | 2770 |
| 31-35 | -- | 20400 | 23200 |
| 51-55 | 544 J | 737 | 396 (413) |
| 63-67 | -- | 208 | 146 |

**SB-31**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 15-19 | -- | 21.0 | 431 |

**SB-25**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 41-45 | -- | 442 | 734 |
| 61-65 | -- | 501 | 924 |

**SB-33**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 11-15 | -- | 647 | 113 |
| 41-45 | -- | 649 | 961 |
| 66-70 | 914 J | 944 | 1230 (1170) |

**SB-34**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 51-55 | -- | 14.6 | 1.36 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 40 120ft

N

LEGEND

- Monitoring Well Location
  A: Perched
  B: Alluvial
- Plugged Monitoring Well
- Permitted NPDES Outfall
- Interceptor Trench Sump
- Soil Boring Location
- Property Boundary
- J Indicates Estimated Concentration

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02
Sep 3, 2019

GROUNDWATER SAMPLING RESULTS - WEST EXTENSION POND

FIGURE 7

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg


**SB-40**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 24-28 | -- | 25.7 | 1460 |

**SB-41**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 15-19 | -- | 8980 | 10900 |

**SB-38**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 41-45 | -- | 13.2 | 1.58 |
| 64-68 | -- | 3.48 | 0.755 |

**SB-42**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 62-66 | 6.2 | 17.4 | 7.62 (0.50) |

**SB-45**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 29-33 | -- | 2.13 | 324 |
| 62-66 | -- | 2.28 | 0.634 |

**SB-37**

| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
|---|---|---|---|
| 11-15 | -- | 3.20 | 2.19 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 200 400ft

LEGEND

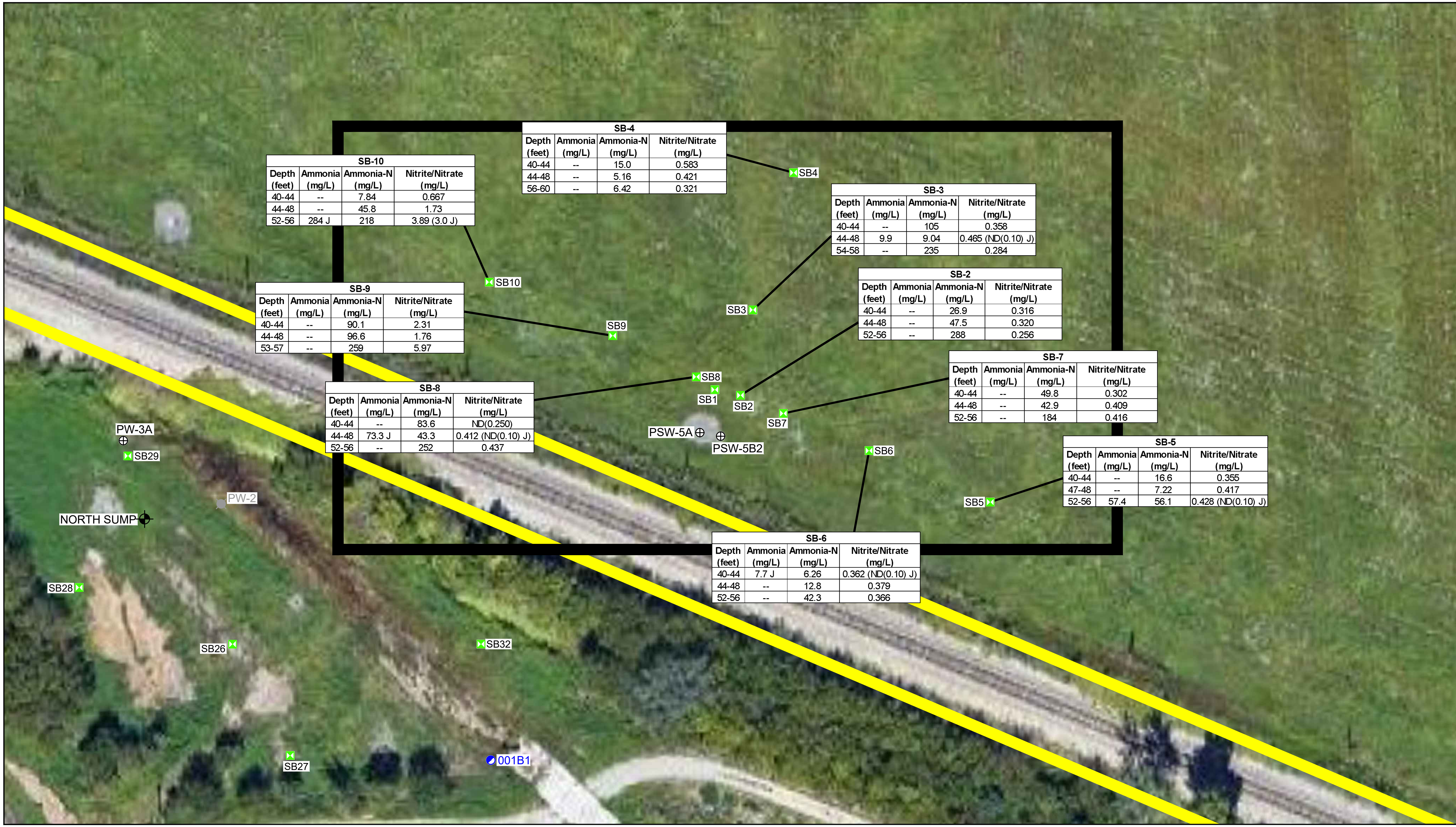
- Monitoring Well Location
  A: Perched
  B: Alluvial
- Plugged Monitoring Well
- Groundwater Recovery Well
- Interceptor Trench Sump
- Soil Boring Location
- Property Boundary

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

11152783-02
Sep 3, 2019

GROUNDWATER SAMPLING RESULTS - EAST AND WEST LIME PONDS FIGURE 8

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg




| SB-10 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 7.84 | 0.667 |
| 44-48 | -- | 45.8 | 1.73 |
| 52-56 | 284 J | 218 | 3.89 (3.0 J) |

| SB-4 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 15.0 | 0.583 |
| 44-48 | -- | 5.16 | 0.421 |
| 56-60 | -- | 6.42 | 0.321 |

| SB-3 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 105 | 0.358 |
| 44-48 | 9.9 | 9.04 | 0.465 (ND(0.10) J) |
| 54-58 | -- | 235 | 0.284 |

| SB-2 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 26.9 | 0.316 |
| 44-48 | -- | 47.5 | 0.320 |
| 52-56 | -- | 288 | 0.256 |

| SB-9 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 90.1 | 2.31 |
| 44-48 | -- | 96.6 | 1.76 |
| 53-57 | -- | 259 | 5.97 |

| SB-7 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 49.8 | 0.302 |
| 44-48 | -- | 42.9 | 0.409 |
| 52-56 | -- | 184 | 0.416 |

| SB-8 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 83.6 | ND(0.250) |
| 44-48 | 73.3 J | 43.3 | 0.412 (ND(0.10) J) |
| 52-56 | -- | 252 | 0.437 |

| SB-5 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | -- | 16.6 | 0.355 |
| 47-48 | -- | 7.22 | 0.417 |
| 52-56 | 57.4 | 56.1 | 0.428 (ND(0.10) J) |

| SB-6 | | | |
|---|---|---|---|
| Depth (feet) | Ammonia (mg/L) | Ammonia-N (mg/L) | Nitrite/Nitrate (mg/L) |
| 40-44 | 7.7 J | 6.26 | 0.362 (ND(0.10) J) |
| 44-48 | -- | 12.8 | 0.379 |
| 52-56 | -- | 42.3 | 0.366 |

Source: GOOGLE AERIAL IMAGE DATED SEPTEMBER 21, 2018

0 20 50ft

N

LEGEND

- Monitoring Well Location
  A: Perched
  B: Alluvial
- Soil Boring Location
- Permitted NPDES Outfall
- Interceptor Trench Sump
- Property Boundary
- ND Not Detected
- J Indicates Estimated Concentration

FORMER FARMLAND INDUSTRIES NITROGEN PLANT
2018 DATA GAP STUDY REPORT
1608 N 1400 ROAD, LAWRENCE, KANSAS

GROUNDWATER SAMPLING RESULTS - PSW-5A

11152783-02

Sep 3, 2019

FIGURE 9

CAD File: I:\CAD\Files\Eight Digit Job Numbers\1115----\11152783-Lawrence_Farmland\Reports\11152783-02(002)Farmland Data Gap\11152783-02(002)GN-DL001.dwg

# Appendix C
# Groundwater Inorganic Analyses, Select Monitoring Wells – October 2019

Farmland Remediation
City of Lawrence
Inorganic Analytical Summary - October 23, 2019

| **Location** | **N-1** | **N-2** | **PSW-5A** | **PSW-5B2** | **PSW-9B** | **PSW-13A** | **PSW-13B** | **PSW-17** | **SW-10** | **PSW-6B3/4** | **PSW-7B2** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| **Analyte** | | | | | | | | | | | |
| Chloride, mg/L | **39** | **4** | **3** | **28** | **24** | **6** | **6** | **8** | **190** | **22** | **33** |
| Sulfate, mg/L | **140** | **22** | **62** | **1,700** | **20** | **32** | **29** | **92** | **160** | **51** | **42** |
| Calcium, ug/L | **1,100,000** | **158,000** | **91,600** | **342,000** | **91,600** | **377,000** | **763,000** | **159,000** | **109,000** | **96,900** | **109,000** |
| Chromium, ug/L | **7** | ND | ND | ND | ND | ND | **22** | ND | ND | ND | ND |
| Iron, ug/L | **2,030** | **86** | **289** | **13,700** | **632** | ND | **28,400** | ND | **11,400** | **9,700** | **8,240** |
| Magnesium, ug/L | **265,000** | **11,700** | **13,200** | **75,400** | **6,610** | **51,300** | **98,500** | **13,700** | **22,200** | **11,300** | **13,000** |
| Manganese, ug/L | **399** | **2,090** | **9** | **4,400** | **167** | **4,650** | **6,040** | **77** | **941** | **472** | **348** |
| Potassium, ug/L | **35,200** | **1,670** | **2,270** | **13,700** | **3,920** | **10,100** | **4,420** | **4,280** | **2,190** | **1,610** | **1,580** |
| Sodium, ug/L | **160,000** | **6,090** | **55,600** | **56,300** | **9,740** | **25,100** | **45,600** | **38,600** | **95,400** | **25,200** | **21,000** |
| Ammonia as N, mg/L | **15,600** | **121** | ND | **114** | ND | **209** | **20** | ND | **4** | **3** | **1** |
| Bicarbonate Alkalinity, mg/L | **2,580** | **147** | **357** | **241** | **210** | **235** | **256** | **312** | **212** | **297** | **319** |
| Carbonate Alkalinity, mg/L | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Nitrate/Nitrite as N, mg/L | **13,700** | **195** | **1** | ND | **11** | **479** | **704** | **51** | **3** | **1** | ND |

Note: All analyses performed by the City of Lawrence Laboratory

City of Lawrence Laboratories - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

November 07, 2019

Sarah Graves
City of Lawrence - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044

RE: NPDES Farmland - Groundwater

Enclosed are the results of analyses for samples received at the laboratory on 10/24/19. The results herein unless otherwise noted, conform to the TNI standards and the laboratory's procedures. The quantitative results in this report relate only to the samples tested.

If you have any questions concerning this report, please feel free to contact me.

DRAFT REPORT
DATA SUBJECT TO CHANGE

(785) 423-0279

*Your feedback for the laboratory services we provide will be greatly appreciated . If you have any input, both positive or negative, let us know by contacting us at jtoevs@lawrenceks.org. Your feedback will be used to improve our management system, testing, and services.*

City of Lawrence

**City of Lawrence Laboratory - Municipal Services and Operations**
**P.O. Box 708**
**Lawrence, KS 66044**
**785-832-7817**

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## ANALYTICAL REPORT FOR SAMPLES

| Sample ID | Laboratory ID | Matrix | Date Sampled | Date Received |
|---|---|---|---|---|
| N-1 | W9J0639-01 | Water | 10/23/19 09:22 | 10/24/19 07:59 |
| N-2 | W9J0639-02 | Water | 10/23/19 09:45 | 10/24/19 07:59 |
| PSW-5A | W9J0639-03 | Water | 10/23/19 15:06 | 10/24/19 07:59 |
| PSW-5B2 | W9J0639-04 | Water | 10/23/19 14:46 | 10/24/19 07:59 |
| PSW-9B | W9J0639-05 | Water | 10/23/19 13:59 | 10/24/19 07:59 |
| PSW-13A | W9J0639-06 | Water | 10/23/19 10:38 | 10/24/19 07:59 |
| PSW-13B | W9J0639-07 | Water | 10/23/19 10:21 | 10/24/19 07:59 |
| PSW-17 | W9J0639-08 | Water | 10/23/19 11:14 | 10/24/19 07:59 |
| SW-10 | W9J0639-09 | Water | 10/23/19 13:29 | 10/24/19 07:59 |
| PSW-6B3/4 | W9J0639-10 | Water | 10/23/19 12:16 | 10/24/19 07:59 |
| PSW-7B2 | W9J0639-11 | Water | 10/23/19 12:41 | 10/24/19 07:59 |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## N-1

Collected: 10/23/19 9:22

**W9J0639-01 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 39 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 140 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 1100000 | 400 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | 7.20 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 2030 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 265000 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 399 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 35200 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 160000 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 15600 | 0.300 | mg/L | 9102412 | 10/24/19 12:41 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 2580 | 120 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 120 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 13700 | 0.250 | mg/L | 9102510 | 10/25/19 10:44 | JNS | EPA 353.2 | |

## N-2

Collected: 10/23/19 9:45

**W9J0639-02 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 3.6 | 2.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 22 | 2.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 158000 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 9:45

**W9J0639-02 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Iron | 85.9 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 11700 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 2090 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 1670 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 6090 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 121 | 0.300 | mg/L | 9102412 | 10/24/19 13:22 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 147 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 195 | 0.250 | mg/L | 9102510 | 10/25/19 10:45 | JNS | EPA 353.2 | |

**PSW-5A**

Collected: 10/23/19 15:06

**W9J0639-03 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 2.6 | 1.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 62 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 91600 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 289 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 13200 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 9.40 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 2270 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 55600 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | ND | 0.300 | mg/L | 9102412 | 10/24/19 12:44 | KEZ | EPA 350.1 | |

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 15:06

**W9J0639-03 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Bicarbonate Alkalinity | 357 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 0.500 | 0.250 | mg/L | 9102510 | 10/25/19 10:46 | JNS | EPA 353.2 | |

**PSW-5B2**

Collected: 10/23/19 14:46

**W9J0639-04 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 28 | 2.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 1700 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 342000 | 200 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Iron | 13700 | 50.0 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 75400 | 50.0 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 4400 | 5.00 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 13700 | 500 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 56300 | 500 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 114 | 0.300 | mg/L | 9102415 | 10/24/19 15:24 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 241 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | 9102510 | 10/25/19 10:47 | JNS | EPA 353.2 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## PSW-9B

Collected: 10/23/19 13:59

**W9J0639-05 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 24 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 20 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 91600 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 632 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 6610 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 167 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 3920 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 9740 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | ND | 0.300 | mg/L | 9102415 | 10/24/19 15:28 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 210 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 10.9 | 0.250 | mg/L | 9102510 | 10/25/19 10:48 | JNS | EPA 353.2 | |

## PSW-13A

Collected: 10/23/19 10:38

**W9J0639-06 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 6.1 | 1.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 32 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 377000 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 10:38

**W9J0639-06 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Iron | ND | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 51300 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 4650 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 10100 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 25100 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 209 | 0.300 | mg/L | 9102415 | 10/24/19 15:33 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 235 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 479 | 0.250 | mg/L | 9102510 | 10/25/19 10:49 | JNS | EPA 353.2 | |

**PSW-13B**

Collected: 10/23/19 10:21

**W9J0639-07 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 6.2 | 1.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 29 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 763000 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | 21.8 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 28400 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 98500 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 6040 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 4420 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 45600 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 19.6 | 0.300 | mg/L | 9102415 | 10/24/19 15:35 | KEZ | EPA 350.1 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 10:21

**W9J0639-07 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Bicarbonate Alkalinity | 256 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 704 | 0.250 | mg/L | 9102512 | 10/25/19 12:15 | JNS | EPA 353.2 | |

**PSW-17**

Collected: 10/23/19 11:14

**W9J0639-08 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 8.3 | 1.0 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 92 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 159000 | 200 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Iron | ND | 50.0 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 13700 | 50.0 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 77.1 | 5.00 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 4280 | 500 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 38600 | 500 | ug/L | 9110710 | 10/25/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | ND | 0.300 | mg/L | 9102415 | 10/24/19 15:37 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 312 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 50.7 | 0.250 | mg/L | 9102512 | 10/25/19 12:16 | JNS | EPA 353.2 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
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Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## SW-10

Collected: 10/23/19 13:29

**W9J0639-09 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 190 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 160 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 109000 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 11400 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 22200 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 941 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 2190 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 95400 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 4.06 | 0.300 | mg/L | 9102415 | 10/24/19 15:39 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 212 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 3.12 | 0.250 | mg/L | 9102512 | 10/25/19 12:18 | JNS | EPA 353.2 | |

## PSW-6B3/4

Collected: 10/23/19 12:16

**W9J0639-10 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 22 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 51 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 96900 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 12:16

**W9J0639-10 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Iron | 9700 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 11300 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 472 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 1610 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 25200 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 3.09 | 0.300 | mg/L | 9102415 | 10/24/19 15:40 | KEZ | EPA 350.1 | |
| Bicarbonate Alkalinity | 297 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | 0.827 | 0.250 | mg/L | 9102512 | 10/25/19 12:19 | JNS | EPA 353.2 | |

**PSW-7B2**

Collected: 10/23/19 12:41

**W9J0639-11 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Chloride | 33 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| Sulfate | 42 | 10 | mg/L | 9110710 | 11/05/19 10:02 | SUB | 300 | |
| | | | | | | Pace Analytical | | |
| Calcium | 109000 | 200 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Chromium | ND | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Iron | 8240 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Magnesium | 13000 | 50.0 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Manganese | 348 | 5.00 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Potassium | 1580 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| Sodium | 21000 | 500 | ug/L | 9110710 | 10/28/19 10:02 | SUB | EPA 200.7 | |
| | | | | | | Pace Analytical | | |
| Ammonia as N | 1.27 | 0.300 | mg/L | 9102415 | 10/24/19 15:42 | KEZ | EPA 350.1 | |

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

Collected: 10/23/19 12:41

**W9J0639-11 (Water)**

| Analyte | Result | Reporting Limit | Units | Batch | Analyzed | Analyst | Method | Qualifiers |
|---|---|---|---|---|---|---|---|---|
| Bicarbonate Alkalinity | 319 | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| Carbonate Alkalinity | ND | 20 | mg/L | 9110710 | 10/29/19 10:02 | SUB | SM 2320B | |
| | | | | | | Pace Analytical | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | 9102512 | 10/25/19 12:20 | JNS | EPA 353.2 | |

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## General Chemistry Parameters - Quality Control

## City of Lawrence

| Analyte | Result | Reporting Limit | Units | Spike Level | Source Result | %REC | %REC Limits | RPD | RPD Limit | Qualifier |
|---|---|---|---|---|---|---|---|---|---|---|
| **Batch 9102412 - Ammonia (EPA 350.1)** | | | | | | | | | | |
| **Blank (9102412-BLK1)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **Blank (9102412-BLK2)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **Blank (9102412-BLK3)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **Blank (9102412-BLK4)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **LCS (9102412-BS1)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 4.99 | 0.300 | mg/L | 5.00 | | 99.8 | 90-110 | | | |
| **LCS (9102412-BS2)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.02 | 0.300 | mg/L | 5.00 | | 100 | 90-110 | | | |
| **LCS (9102412-BS3)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 4.95 | 0.300 | mg/L | 5.00 | | 99.0 | 90-110 | | | |
| **LCS (9102412-BS4)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.04 | 0.300 | mg/L | 5.00 | | 101 | 90-110 | | | |
| **Duplicate (9102412-DUP1)** | **Source: W9J0466-01** | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 1.03 | 0.300 | mg/L | | 0.985 | | | 4.47 | 20 | |
| **Matrix Spike (9102412-MS1)** | **Source: W9J0466-02** | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 4.84 | 0.300 | mg/L | 5.30 | ND | 91.2 | 90-110 | | | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## General Chemistry Parameters - Quality Control

## City of Lawrence

| Analyte | Result | Reporting Limit | Units | Spike Level | Source Result | %REC | %REC Limits | RPD | RPD Limit | Qualifier |
|---|---|---|---|---|---|---|---|---|---|---|
| **Batch 9102415 - Ammonia (EPA 350.1)** | | | | | | | | | | |
| **Blank (9102415-BLK1)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **Blank (9102415-BLK2)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **Blank (9102415-BLK3)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | ND | 0.300 | mg/L | | | | | | | |
| **LCS (9102415-BS1)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.18 | 0.300 | mg/L | 5.00 | | 104 | 90-110 | | | |
| **LCS (9102415-BS2)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.09 | 0.300 | mg/L | 5.00 | | 102 | 90-110 | | | |
| **LCS (9102415-BS3)** | | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.10 | 0.300 | mg/L | 5.00 | | 102 | 90-110 | | | |
| **Duplicate (9102415-DUP1)** | **Source: W9J0639-04** | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 113 | 0.300 | mg/L | | 114 | | | 1.47 | 20 | |
| **Matrix Spike (9102415-MS1)** | **Source: W9J0639-05** | | | Prepared & Analyzed: 10/24/19 | | | | | | |
| Ammonia as N | 5.14 | 0.300 | mg/L | 5.30 | ND | 97.0 | 90-110 | | | |
| **Batch 9102510 - Nitrate+Nitrite (EPA 353.2)** | | | | | | | | | | |
| **Blank (9102510-BLK1)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |

City of Lawrence

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**Reported:** 11/07/19 13:59

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## General Chemistry Parameters - Quality Control

## City of Lawrence

| Analyte | Result | Reporting Limit | Units | Spike Level | Source Result | %REC | %REC Limits | RPD | RPD Limit | Qualifier |
|---|---|---|---|---|---|---|---|---|---|---|
| **Batch 9102510 - Nitrate+Nitrite (EPA 353.2)** | | | | | | | | | | |
| **Blank (9102510-BLK2)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |
| **Blank (9102510-BLK3)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |
| **Blank (9102510-BLK4)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |
| **LCS (9102510-BS1)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.44 | 0.250 | mg/L | 5.56 | | 97.9 | 90-110 | | | |
| **LCS (9102510-BS2)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.40 | 0.250 | mg/L | 5.56 | | 97.0 | 90-110 | | | |
| **LCS (9102510-BS3)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.63 | 0.250 | mg/L | 5.56 | | 101 | 90-110 | | | |
| **LCS (9102510-BS4)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.52 | 0.250 | mg/L | 5.56 | | 99.2 | 90-110 | | | |
| **Duplicate (9102510-DUP1)** | **Source: W9J0385-02** | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 9.48 | 0.250 | mg/L | | 9.24 | | | 2.60 | 20 | |
| **Matrix Spike (9102510-MS1)** | **Source: W9J0429-01** | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 23.7 | 0.250 | mg/L | 7.50 | 15.5 | 109 | 90-110 | | | |
| **Batch 9102512 - Nitrate+Nitrite (EPA 353.2)** | | | | | | | | | | |
| **Blank (9102512-BLK1)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
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785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## General Chemistry Parameters - Quality Control

## City of Lawrence

| Analyte | Result | Reporting Limit | Units | Spike Level | Source Result | %REC | %REC Limits | RPD | RPD Limit | Qualifier |
|---|---|---|---|---|---|---|---|---|---|---|
| **Batch 9102512 - Nitrate+Nitrite (EPA 353.2)** | | | | | | | | | | |
| **Blank (9102512-BLK2)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | ND | 0.250 | mg/L | | | | | | | |
| **LCS (9102512-BS1)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.23 | 0.250 | mg/L | 5.56 | | 94.1 | 90-110 | | | |
| **LCS (9102512-BS2)** | | | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 5.73 | 0.250 | mg/L | 5.56 | | 103 | 90-110 | | | |
| **Duplicate (9102512-DUP1)** | | **Source: W9J0639-08** | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 47.0 | 0.250 | mg/L | | 50.7 | | | 7.51 | 20 | |
| **Matrix Spike (9102512-MS1)** | | **Source: W9J0639-09** | | Prepared & Analyzed: 10/25/19 | | | | | | |
| Nitrate/Nitrite as N | 11.0 | 0.250 | mg/L | 7.50 | 3.12 | 104 | 90-110 | | | |





DRAFT REPORT, DATA SUBJECT TO CHANGE

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665

## Notes and Definitions

| | |
|---|---|
| DET | Analyte DETECTED |
| ND | Analyte NOT DETECTED at or above the reporting limit |
| NR | Not Reported |
| dry | Sample results reported on a dry weight basis |
| RPD | Relative Percent Difference |

City of Lawrence

# CHAIN-OF-CUSTODY / Analytical Request / Sample Receiving

| Project Name: Farmland Groundwater | Report To: Name: Sarah Graves<br>Copy to: ______<br>Phone: ☐<br>email: ☑ | Additional Project Information<br>(example: Hillview (South) 2nd Sample, chlorine, pH)<br>A See Pace Analytical COC for additional subcontracted analysis |
|---|---|---|

Work Order #:: W9J0639

| Sample # | Sample ID | Matrix (DW = Drinking Water WT = Water WW = Wastewater S = Soil / Solid/Sludge O = Other) | Sample Type (G=Grab) (C=Composite) | COLLECTION Date | COLLECTION Time | # Containers: Unpreserved | # Containers: Sulfuric Acid-$H_2SO_4$ | # Containers: [Micro] Sterile - $Na_2S_2O_3$ | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| -01 | N-1 | WT | G | 10-23-19 | 0922 | | 1 | | | | |
| -02 | N-2 | WT | G | 10-23-19 | 0945 | | 1 | | | | |
| -03 | PSW-5A | WT | G | 10-23-19 | 1506 | | 1 | | | | |
| -04 | PSW-5B2 | WT | G | 10-23-19 | 1446 | | 1 | | | | |
| -05 | PSW-9B | WT | G | 10-23-19 | 1359 | | 1 | | | | |
| -06 | PSW-13A | WT | G | 10-23-19 | 1038 | | 1 | | | | |
| -07 | PSW-13B | WT | G | 10-23-19 | 1021 | | 1 | | | | |
| -08 | PSW-17 | WT | G | 10-23-19 | 1114 | | 1 | | | | |

ANALYSIS REQUEST

| Sample # | Alkalinity | Ammonia ($NH_3$ as N) | $BOD_5$ | $CBOD_5$ | Calcium Hardness | COD | Conductivity | *E. coli* | Fluoride | Free Ammonia/Monochloramine | Heterotrophic Plate Count (HPC) | Ortho Phosphate as P | Nitrate ($NO_3$ as N)/Nitrite ($NO_2$ as N) | pH / Temperature | Total Chlorine Residual | Total Coliform | Total Dissolved Solids (TDS) | Total Hardness | Total Kjeldahl Nitrogen (TKN) | Total Organic Carbon (TOC / DOC) | Total Phosphorus as P | Total Suspended Solids (TSS) | Turbidity | Volatile Suspended Solids (VSS) | Metals | Metals - Lead | Metals - Copper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -01 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -02 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -03 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -04 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -05 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -06 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -07 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -08 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |

| PERSON COLLECTING THE SAMPLE (PRINT) | RELINQUISHED BY | Date | Time | ACCEPTED BY | Date | Time |
|---|---|---|---|---|---|---|
| Jeff Scott | | | | [signature] | 10-23-19 | 1640 |
| | | | | | | |

NOTE: If person collecting the sample also analyzes the sample, relinquished information is not required.

**Sample Condition Upon Receipt**

Trip Blank Temp: NA °C

| Were Samples: | Y | N | NA | Comment |
|---|---|---|---|---|
| Received on Ice? | X | | | |
| Intact? | X | | | |
| Preserved within 15 min of collection? | | | X | |
| Analyzed within 15 min of collection? | | | X | |



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City of Lawrence

# CHAIN-OF-CUSTODY / Analytical Request / Sample Receiving

| Project Name: Farmland<br>Groundwater | Report To:<br>Name: Sarah Graves<br>Copy to:<br>Phone: ☐<br>email: ☑ | Additional Project Information<br>(example: Hillview (South) 2nd Sample, chlorine, pH)<br>See Pace Analytical COC for additional subcontracted analysis |
|---|---|---|

Work Order #:: W9J0639

| Sample # | Sample ID | Matrix (DW = Drinking Water WT = Water WW = Wastewater S = Soil / Solid/Sludge O = Other) | Sample Type (G=Grab) (C=Composite) | COLLECTION Date | COLLECTION Time | PRESERVATION # Containers: Unpreserved | Sulfuric Acid-$H_2SO_4$ | [Micro] Sterile - $Na_2S_2O_3$ | Comments |
|---|---|---|---|---|---|---|---|---|---|
| -09 | SW-10 | WT | G | 10-23-19 | 1329 | | 1 | | |
| -10 | PSW-6B3/4 | WT | G | 10-23-19 | 1216 | | 1 | | |
| -11 | PSW-7B2 | WT | G | 10-23-19 | 1241 | | 1 | | |

ANALYSIS REQUEST

| Sample # | Alkalinity | Ammonia ($NH_3$ as N) | $BOD_5$ | $CBOD_5$ | Calcium Hardness | COD | Conductivity | *E. coli* | Fluoride | Free Ammonia/Monochloramine | Heterotrophic Plate Count (HPC) | Ortho Phosphate as P | Nitrate ($NO_3$ as N)/Nitrite ($NO_2$ as N) | pH / Temperature | Total Chlorine Residual | Total Coliform | Total Dissolved Solids (TDS) | Total Hardness | Total Kjeldahl Nitrogen (TKN) | Total Organic Carbon (TOC / DOC) | Total Phosphorus as P | Total Suspended Solids (TSS) | Turbidity | Volatile Suspended Solids (VSS) | Metals | Metals - Lead | Metals - Copper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -09 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -10 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |
| -11 | | X | | | | | | | | | | | X | | | | | | | | | | | | | | |

| PERSON COLLECTING THE SAMPLE (PRINT) | RELINQUISHED BY | Date | Time | ACCEPTED BY | Date | Time |
|---|---|---|---|---|---|---|
| Jeff Scott | | | | [signature] | 10-23-19 | 1640 |

NOTE: If person collecting the sample also analyzes the sample, relinquished information is not required.

**Sample Condition Upon Receipt**

Trip Blank Temp: NA °C

| Were Samples: | Y | N | NA | Comment |
|---|---|---|---|---|
| Received on Ice? | X | | | |
| Intact? | X | | | |
| Preserved within 15 min of collection? | | | X | |
| Analyzed within 15 min of collection? | | | X | |



\\utilities\Water_Quality\Shared\Quality Systems\Forms\Controlled\COC_03262019

| Turbidimeter Verification | | |
|---|---|---|
| Chemical | Lot # | Exp Date |
| Gelex Standard (0-2 NTU) | | |

| Turbidity Verification | | Initial | | Final | |
|---|---|---|---|---|---|
| Gelex Assigned Value | Acceptable Value (± 5%) | NTU | % Recovery | NTU | % Recovery |
| | | | | | |
| | | | Must be 90-110% | | Must be 90-110% |

| pH Meter Calibration | | |
|---|---|---|
| Chemical | Lot # | Exp Date |
| HACH pH 4.0 | A8338 | 12-5-22 |
| HACH pH 7.0 | A8345 | 12-12-20 |
| HACH pH 10.0 | A8352 | 12-19-19 |
| Fisher pH 6.0 | 4801F29 | 1-31-20 |
| Fisher pH 9.0 | 188959 | 1-31-21 |

| pH | Initial pH | | Ending pH | |
|---|---|---|---|---|
| Calibration Slope | pH 9.0 Reading S.U. | Recovery | pH 6.0 Reading S.U. | Recovery |
| -57.94 | 9.00 | 0.0 | 6.04 | +0.04 |
| -55 to -61 mV | | Must be +/- 0.1 SU | | Must be +/- 0.1 SU |

| Conductivity Meter Calibration | | |
|---|---|---|
| Chemical | Lot # | Exp Date |
| Hach Sodium Chloride Std Soln. | A7153 | 5-26-22 |
| Fisher Sodium Chloride Std Soln. | CC18352 | 4-8-20 |

| Initial Conductivity | | Ending Conductivity | |
|---|---|---|---|
| 1000 / ~~1413~~ 1410 uS/cm | % Recovery | 1000 / ~~1413~~ 1410 uS/cm | % Recovery |
| 1399 | 99.2 | 1421 | 100.7 |
| | Must be 90-110% | | Must be 90-110% |

| Dissolved Oxygen HQ40d Slope % |
|---|
| |
| Must be 76.9-133% |

| Work Order #: | | | Analysis date/time | | SM 2130 B | SM 4500-H B EPA9040 EPA9045 | SM 2550 B | SM 4500-O G | SM 2540D EPA9050A | <--Circle correct method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Analyst | Date | Time | Turbidity (NTU) | pH (S.U.) | Temp (°C) | DO (mg/L) | Conductivity (uS/cm) | Strm Flow (CFS) | Strm_Depth (FT) | Strm_Level (Code) | Strm_Vel (Code) | Rainfall (Inches) |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

Comments:

City of Lawrence Laboratory - Municipal Services and Operations
P.O. Box 708
Lawrence, KS 66044
785-832-7817

**Reported:** 11/07/19 13:59

**NELAP Laboratory Accreditation:** E-60665 about

# GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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