Location Restrictions Assessment
Lawrence Energy Center
Industrial Landfill #0847

Prepared for:

Westar Company

Lawrence Energy Center

Lawrence, Kansas

Prepared by:

APTIM Environmental & Infrastructure, Inc.

March 2018

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§257.60(a) stipulates: *"(a) New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must be constructed with a base that is located no less than 1.52 meters (five feet) above the upper limit of the uppermost aquifer, or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations (including the seasonal high water table). The owner or operator must demonstrate by the dates specified in paragraph (c) of this section that the CCR unit meets the minimum requirements for placement above the uppermost aquifer."*	Section 3.1
§257.61(a) stipulates: *"(a) New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in wetlands, as defined in §232.2 of this chapter, unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that the CCR unit meets the requirements of paragraphs (a)(1) through (5) of this section."*	Section 3.2

APTIM

USEPA CCR Rule Criteria 40 CFR §257.60-.64	Lawrence Energy Center (LEC) Location Restriction Assessment
§257.62(a) stipulates: *"(a) New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that an alternative setback distance of less than 60 meters (200 feet) will prevent damage to the structural integrity of the CCR unit."*	Section 3.3
§257.63(a) stipulates: *"(a) New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in seismic impact zones unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site."*	Section 3.4
§257.64(a) stipulates: *"(a) An existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit must not be located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted."*	Section 3.5

USEPA CCR Rule Criteria 40 CFR §257.60-.64	**Lawrence Energy Center (LEC) Location Restriction Assessment**
§257.64(b) stipulates: *"(b) The owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable:* *(1) On-site or local soil conditions that may result in significant differential settling;* *(2) On-site or local geologic or geomorphologic features; and* *(3) On-site or local human-made features or events (both surface and subsurface)."*	Section 3.5
§§257.60(b), 257.61(b), 257.62(b), 257.63(b), 257.64(c) stipulates: *"The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the demonstration meets the requirements of paragraph (a) of this section."*	Section 5.0
§§257.60(c), 257.61(c), 257.62(c), 257.63(c), 257.64(d) stipulates: *The owner or operator of the CCR unit must complete the demonstration required by paragraph (a) of this section by the date specified in either paragraph (c)(1) or (2) (or (d)(1) or (2) for §257.64) of this section.* *(1) For an existing CCR surface impoundment, the owner or operator must complete the demonstration no later than October 17, 2018.* *(2) For a new CCR landfill, new CCR surface impoundment, or any lateral expansion of a CCR unit, the owner or operator must complete the demonstration no later than the date of initial receipt of CCR in the CCR unit.*	Section 1.0

USEPA CCR Rule Criteria 40 CFR §257.60-.64	Lawrence Energy Center (LEC) Location Restriction Assessment
§§257.60(c)(3)-.63(c)(3) and 257.64(d)(3) stipulates: *(3) The owner or operator has completed the demonstration required by paragraph (a) of this section when the demonstration is placed in the facility's operating record as required by §257.105(e).*	Section 4.1
§§257.60(c)(4) and (5)-.63(c)(4) and (5), and 257.64(d)(4) and (5) stipulates: *(4) An owner or operator of an existing CCR surface impoundment who fails to demonstrate compliance with the requirements of paragraph (a) of this section by the date specified in paragraph (c)(1) (or (d)(1) for §257.64) of this section is subject to the requirements of §257.101(b)(1) (or (d)(1)).* *(5) An owner or operator of a new CCR landfill, new CCR surface impoundment, or any lateral expansion of a CCR unit who fails to make the demonstration showing compliance with the requirements of paragraph (a) of this section is prohibited from placing CCR in the CCR unit.*	Not applicable. Demonstrations were completed on time and in compliance.
§§257.60(d), 257.61(d), 257.62(d), 257.63(d), 257.64(e) stipulates: *"The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in §257.105(e), the notification requirements specified in §257.106(e), and the internet requirements specified in §257.107(e)."*	Section 4.2

1.0 INTRODUCTION

Aptim Environmental and Infrastructure, Inc. (APTIM, f/k/a CB&I Environmental & Infrastructure, Inc.) has prepared the following Location Restrictions Assessment (Assessment) at the request of Westar Energy (Westar) for the Industrial Landfill No. 0847 (Landfill) located at the Lawrence Energy Center (LEC) in Lawrence, Kansas. LEC is a coal-fired power plant that was initially commissioned in 1938. The Landfill has been deemed to be a regulated coal combustion residual (CCR) unit by the United States Environmental Protection Agency (USEPA), through the Disposal of Coal Combustion Residuals from Electric Utilities Final Rule (CCR Rule) 40 CFR 257 and §261.

This Assessment meets the requirements set forth within 40 CFR §§257.60-257.64 based the review of available information and visual observation, to evaluate if:

- ❑ Cells 4-8 are no less than 5 feet from the upper limit of the uppermost aquifer (40 CFR §257.60);
- ❑ Cells 4-8 are not located in wetlands (40 CFR §257.61);
- ❑ Cells 4-8 are not within 200 feet of the outermost damage zone of a fault which has been displaced in Holocene time (40 CFR §257.62);
- ❑ Cells 4-8 are not within a seismic impact zone (40 CFR §257.63); and
- ❑ Cells 1-8 are not located in an unstable area (40 CFR §257.64).

The Assessment has been conducted and completed in compliance timeframe set forth in §§257.60(c)-257.63(c) and §257.64(d).

2.0 LEC LANDFILL OVERVIEW

Westar owns and operates an industrial landfill at LEC near Lawrence, Douglas County, Kansas. LEC resides in Section 14, Township 12 South, Range 19 East. The Landfill is located on the east side of LEC. The Landfill is surrounded by the Kansas River to the north, the Burlington Northern and Santa Fe railway along the north and east, prairies and industrial buildings to the south, and the LEC power plant to the west. The location of the Landfill is depicted in **Figure 1**.

The Landfill is divided into eight cells designated Cell 1-8. Phased construction at the Landfill will occur in numerical order. Cell 1 is approximately 13.8 acres within the northwest corner of the permitted Landfill boundary. Cell 1 shares a border with a closed landfill adjacent to Cell 1. The closed landfill is permitted under Kansas Department of Health and Environment (KDHE) Bureau of Waste Management (BWM) (KDHE-BWM) Permit No. 0333. Cells 2 and 3 are 6.5 acres and 5.2 acres respectfully, located east of Cell 1. In total, the completed Landfill will be approximately 57.3 acres. Phased construction of the cells will continue in sequential order at the Landfill until all cells are completed and closed in accordance with the permitted design and in line with the CCR regulations. Existing site topography is depicted in **Figure 2.**

CCR material is transported to the active portion of the Landfill, where it is unloaded and graded by dozers and compacted. Periodic dozing of the CCR material will occur as needed, within the active area to maintain a relatively uniform grade. The CCR material will be wetted prior to the final cover placement and will form a hardened surface as it dries.

A proposed redesign of Cells 4-8 for the Landfill has recently been submitted and reviewed by KDHE-BWM. The design included revised final waste grades for Cells 1-8. The proposed total landfill disposal capacity for the Landfill was determined to be 4,944,129 cy.

3.0 LOCATION RESTRICTIONS

The location restrictions for required under the Rule for Cells 4-8 (i.e. lateral expansions) include:

- ❑ §257.60 - Placement above the uppermost aquifer
- ❑ §257.61 - Wetlands
- ❑ §257.62 - Fault areas
- ❑ §257.63 - Seismic impact zones
- ❑ §257.64 - Unstable areas

It should be noted that the areas of the Landfill receiving CCR prior to October 2015 (i.e. Cells 1-3) are required to be evaluated for unstable areas. As previously stated, Cells 4-8 are required to be evaluated for all of the location restriction requirements.

APTIM reviewed the available information for the Landfill as provided by Westar:

- ❑ 2017 Annual Groundwater Monitoring and Corrective Action Report Ash Landfill 847 Lawrence Energy Center, Haley & Aldrich, Inc., January 2018.

- ❑ Annual Inspection Report Lawrence Energy Center Industrial Landfill #0847, Lawrence Energy Center Annual Landfill Inspection – 2016, CB&I Environmental & Infrastructure, Inc., January, 2017.

- ❑ Annual Inspection Report Lawrence Energy Center Industrial Landfill #0847, Lawrence Energy Center Annual Landfill Inspection – 2017, APTIM Environmental & Infrastructure, Inc., January, 2018.

- ❑ CCR Groundwater Monitoring Network Description for the Lawrence Energy Center, Lawrence, Kansas, Haley & Aldrich, Inc., June 2016.

- ❑ Kansas Department of Health and Environment – Bureau of Waste Management (KDHE-BWM) Industrial Landfill Permit No. 0847, October 15, 2015.

- ❑ Lawrence Energy Center Comprehensive Design Modification Report Industrial Landfill #0847, APTIM Environmental & Infrastructure, Inc., November, 2017.

- ❑ Phase II Hydrogeologic Site Investigation, Black & Veatch, January 2005.

3.1 Placement above the Uppermost Aquifer (§257.60(a))

The site geology was characterized by Black & Veatch for the Phase II Hydrogeologic Site Investigation performed in January 2005 (see **Appendix A**). As described in the Phase II Investigation, the generalized geology underlying the Landfill includes the following, from top to bottom:

1. Silt and Clay (Sappa Formation)
2. Sand and Gravel (Grand Island Formation)
3. Bedrock (Lawrence Shale Formation)

The silt and clay deposits consist of clay, sandy clay, silty clay, clayey silt, and sandy silt. A low cohesive layer below the sand and gravel deposit and above the bedrock was encountered at some borings, which ranged in thickness from 0.5 feet to 6.5 feet and consists of sandy clay, silty clay, and clay and may be residual, weathered shale.

KDHE-BWM has subsequently stated that the Lawrence Shale Formation is not considered the uppermost aquifer due to insufficient groundwater yield to wells or springs. Based on the definition of aquifer in §257.53, the true uppermost is located in the Ireland sandstone which is located below the Lawrence Shale Formation.

The base liner of Cells 4-8 was designed to have a minimum elevation of approximately 852.2 ft MSL, located in Cell 4, as depicted in **Figure 3**. During the construction of the monitoring well network in 2016, it was recorded that the shallowest water elevation level in the Ireland sandstone was approximately 818.3 ft MSL. This was confirmed as the shallowest recorded water elevation from a review of the groundwater monitoring data for the Ireland sandstone from 2016 through 2017. Therefore can be concluded that the base liner of Cells 4-8 has a minimum invert elevation no less than 5 feet above the uppermost aquifer, per §257.60(a).

3.2 Wetlands (§257.61(a))

Cells 4-8 of the Landfill are not located within a wetland as defined in §232.2, per §257.61(a). This was determined using the U.S. Fish and Wildlife Services, National Wetlands Inventory Surface Waters and Wetlands Map. See **Figure 5** for the location of the nearest wetlands.

3.3 Fault Areas (§257.62(a))

The site is not located within 200 feet of the outermost damage zone of a fault that has had displacement in the Holocene time. This was determined using the United States Geologic Survey (USGS) Quaternary Fault and Fold Database for the United States. See **Figure 6** for the nearest fault area.

3.4 Seismic Impact Zones (§257.63(a))

It is required by §257.63(a) that the Landfill must be not be located in seismic impact zones or it must be demonstrated that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material. Based on these requirements and the definition of maximum horizontal acceleration in lithified earth material in §257.53, it was determined from the USGS Earthquake Hazards Program – National Seismic Hazard Mapping website, that the seismic coefficient for the Landfill site area is 4.66% at a probability of 2% in 50 years. See **Figure 7** for the maximum horizontal acceleration for the site.

Geotechnical analyses have been performed for the Cells 4-8 proposed design in order to verify that the liner, leachate collection and removal system, and final cover will be stable during construction, operation, and following closure of the Landfill, under seismic and static conditions. Analyses included chemical compatibility (§257.70(b-d)), pipe strength (§257.70(d)), leachate head (§257.70(d)), pipe capacity, leachate collection system geocomposite (geonet) capacity, and liner equivalency analyses (§257.70(c)). These analyses in the design report demonstrate that the Landfill will be stable and that the structural integrity will be maintained over the life of the landfill and beyond. The site was designed with factors of safety of 1.3 for this seismic activity peak horizontal acceleration.

3.5 Unstable Areas (§257.64(a) and (b))

Per §257.64 of the Rule, Cells 1-8 of the Landfill must complete a demonstration that the Landfill is not located within an unstable area. Specifically, demonstration must be provided that the Landfill is located such that it is not:

> *"…located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.*"

There are no documented unstable areas located beneath the excavation of the Landfill. There are no reported karst areas within the proposed facility boundary. Site specific studies have not identified site characteristics that are conducive to the formation of karst features nor the presence of coal mining.

As previously mentioned, the site was characterized in the Phase II Site Investigation as silt and clay deposits (consisting of clay, sandy clay, silty clay, clayey silt, and sandy silt) ranging in thickness from 7 feet to 55 feet, a granular deposit layer (consisting of sand, gravelly sand, and clayey sand) ranging in thickness of 5 feet to 28 feet, and the bedrock. A low cohesive layer below the sand and gravel deposit and above the bedrock was encountered at some borings. Based on this description, it is anticipated that the soils on site will not be likely to experience significant differential settlement.

The assessments did not reveal any unstable areas, including any evidence of coal mines or karst formations. It was concluded in the Phase II Investigation:

> *"No unusual geologic features, such as fault zones, buried stream deposits, or cross cutting structures, were identified that will affect the ability to detect a release from the landfill."*

The Landfill has been developed in stable soils and has been designed to account for seismic activity. It is the opinion of APTIM that the design of the CCR unit has been appropriately located and designed to ensure that the integrity of the structural components of the CCR unit such that they will not be disrupted.

4.0 RECORDS RETENTION AND MAINTENANCE (§§257.60(d), 257.61(d), 257.62(d), 257.63(d), 257.64(e))

4.1 Incorporation of Plan into Operating Record

§257.105(e) of 40 CFR Part §257 provides record keeping requirements to ensure that this Assessment will be placed in LEC's operating record. Specifically, §257.105(e) stipulates:

> §257.105(e)*: "(e) Location restrictions. The owner or operator of a CCR unit subject to this subpart must place the demonstrations documenting whether or not the CCR unit is in compliance with the requirements under §§257.60(a), 257.61(a), 257.62(a), 257.63(a), and 257.64(a), as it becomes available in the facility's operating record."*

This Assessment will be placed within the Facility Operating Record upon Westar's review and approval, per §§257.105(e), 257.60(c)(3), 257.61(c)(3), 257.62(c)(3), 257.63(c)(3), and 257.64(d)(3).

4.2 Notification Requirements

§257.106(e) of 40 CFR Part §257 provides guidelines for the notification of the availability of the initial and periodic plan. Specifically, §257.106(e) stipulates:

> §257.106(e): *(e) Location restrictions. The owner or operator of a CCR unit subject to this subpart must notify the State Director and/or appropriate Tribal authority that each demonstration specified under §257.105(e) has been placed in the operating record and on the owner or operator's publicly accessible internet site."*

The State Director and appropriate Tribal Authority will be notified upon placement of this Assessment in the Facility Operating Record.

§257.107(e) of 40 CFR Part §257 provides publicly accessible Internet site requirements to ensure that this Assessment is accessible through the Westar webpage. Specifically, §257.107(e) stipulates:

> §257.107(e): *(e) Location restrictions. The owner or operator of a CCR unit subject to this subpart must place each demonstration specified under §257.105(e) on the owner or operator's CCR Web site."*

This Assessment will be uploaded to Westar's CCR Compliance reporting Website upon Westar's review and approval.

5.0 PROFESSIONAL ENGINEER CERTIFICATION (§§257.60(b), 257.61(b), 257.62(b), 257.63(b), 257.64(c))

The undersigned registered professional engineer is familiar with the requirements of the CCR Rule and has visited and examined LEC or has supervised examination of LEC by appropriately qualified personnel. I hereby certify based on a review of available information within the facility's design, operating records, and observations, that the Landfill meets the requirements in §§257.60(a)-257.64(a). The unit is being operated and maintained consistent with recognized and generally accepted good engineering standards and practices. This certification was prepared as required by 40 CFR Part §§257.60(b)-257.63(b) and §257.64(c).

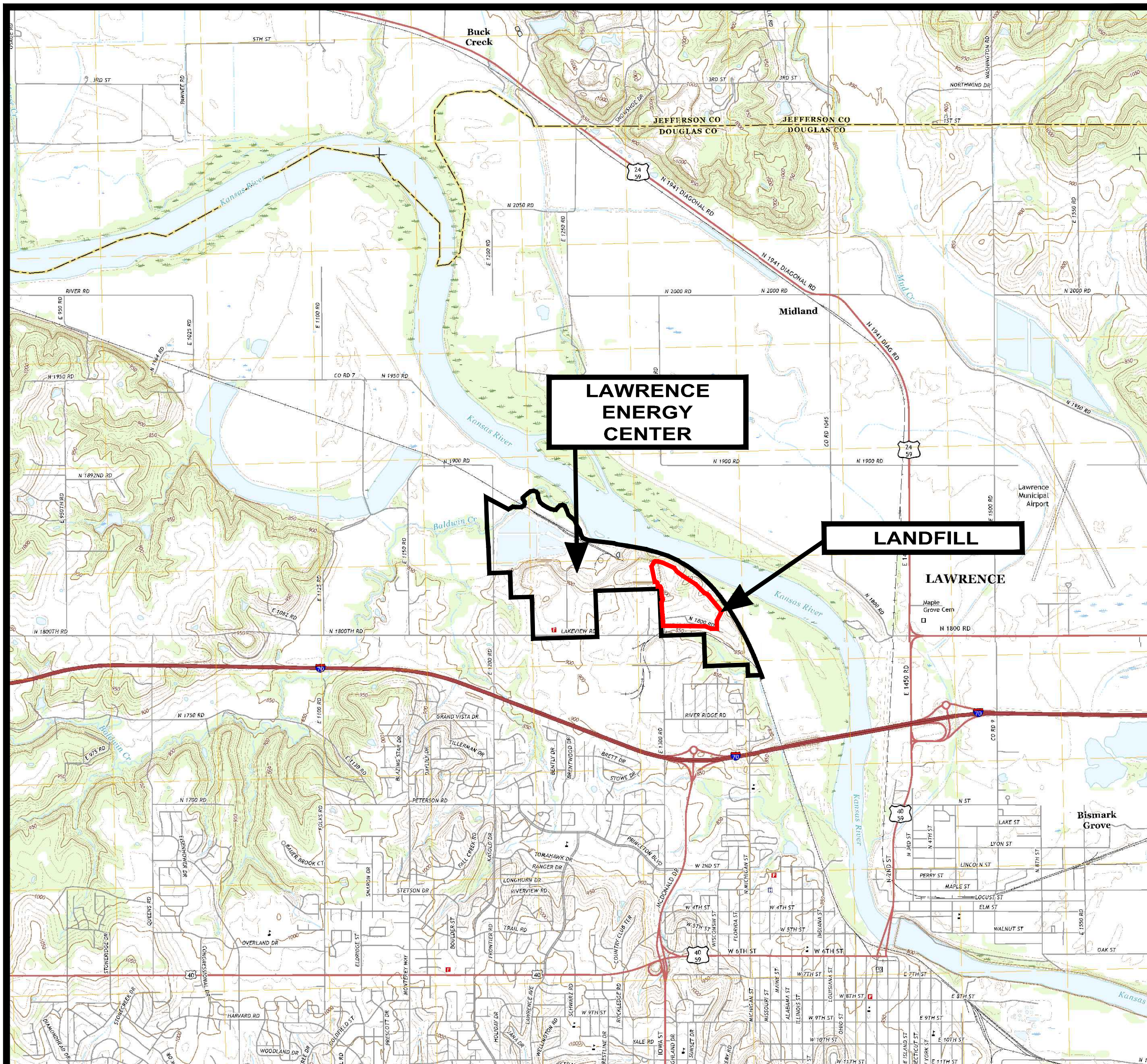
Name of Professional Engineer:	Richard Southorn
Company:	APTIM
Signature:	[signature]
Date:	3/29/18
PE Registration State:	Kansas
PE Registration Number:	PE25201

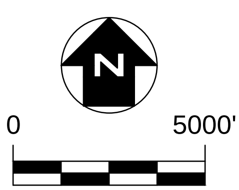
Professional Engineer Seal:

RICHARD DAVID SOUTHORN
LICENSED
25201
KANSAS
PROFESSIONAL ENGINEER

FIGURES

Figure 1 – Site Location Plan
Figure 2 – Existing Site Conditions
Figure 3 – Cells 4-8 Base Liner Overview
Figure 4 – Lawrence Landfill, Wetlands Locations
Figure 5 – Lawrence Landfill, Map of Fault Areas
Figure 6 – Lawrence Landfill, Map of Horizontal Acceleration





LEGEND

LAWRENCE ENERGY CENTER FACILITY BOUNDARY

CCR UNIT BOUNDARY

NOTES

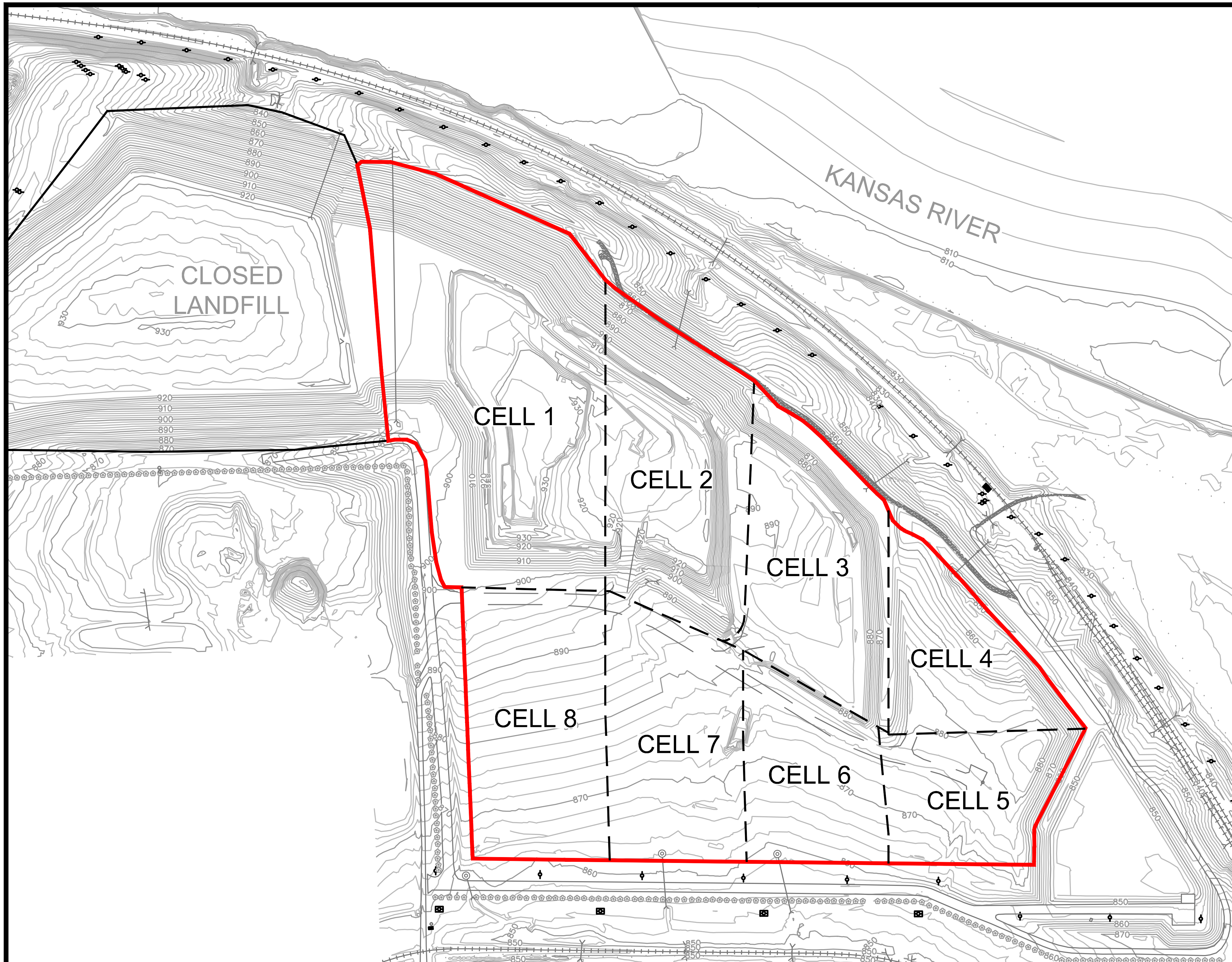
1. AERIAL TOPO OBTAINED FROM USGS 7.5-MINUTE SERIES, LAWRENCE EAST, LAWRENCE WEST, MIDLAND AND WILLIAMSTOWN QUADRANGLE, KANSAS, 2014.
2. ALL BOUNDARIES ARE APPROXIMATE.

APTIM Environmental & Infrastructure, Inc.

LAWRENCE ENERGY CENTER
1250 N. 1800 RD., LAWRENCE, KS.

FIGURE 1
LAWRENCE LANDFILL
SITE LOCATION PLAN

APPROVED BY: RDS	PROJ. NO.: –	DATE: FEBRUARY 2018



N

0 300'

GRAPHIC SCALE

LEGEND

APPROXIMATE CCR UNIT BOUNDARY (solid red line)

APPROXIMATE LANDFILL CELL BOUNDARY (dashed black line)

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY PROFESSIONAL ENGINEERING CONSULTANTS IN JUNE 2016. CONTOURS WERE SUBSEQUENTLY MODIFIED BY APTIM TO REFLECT A RIP-RAP AND SOIL STOCKPILE REMOVAL. EXISTING CONTOURS MAY DIFFER FROM SHOWN.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CCR UNIT BOUNDARY IS APPROX. 53.5 ACRES.
4. ALL BOUNDARIES ARE APPROXIMATE.

REV. NO.	DATE	DESCRIPTION

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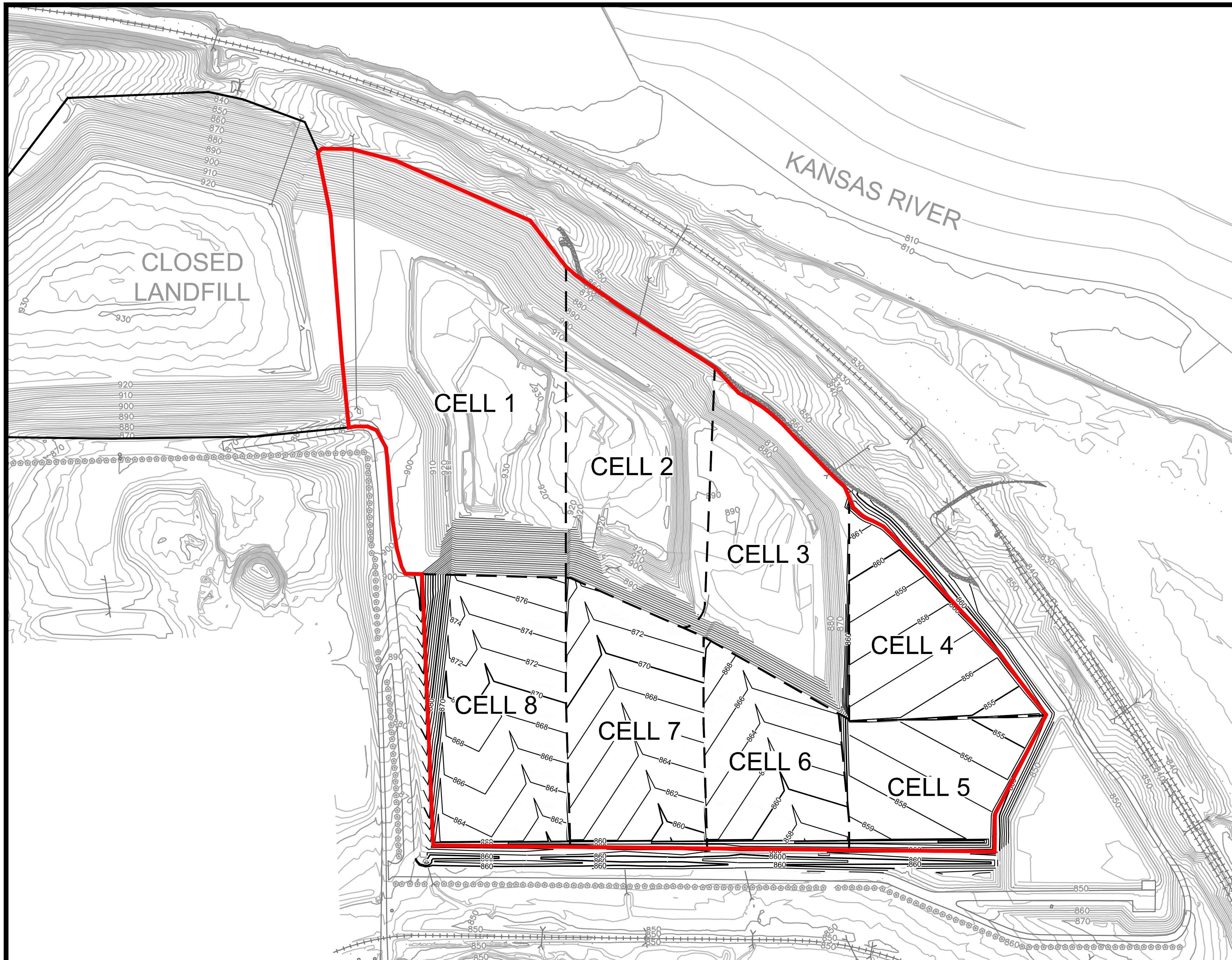
FIGURE 2
LAWRENCE LANDFILL
EXISTING SITE TOPOGRAPHY

DRAWN BY:	ORC	APPROVED BY:	RDS	PROJ. NO.:	631226111	DATE:	MARCH 2018

T:\AutoCAD\Projects\Westar Energy\Lawrence\Location\Lawrence Fig 2.dwg



N

0 300'

GRAPHIC SCALE

LEGEND

- APPROXIMATE CCR UNIT BOUNDARY
- APPROXIMATE LANDFILL CELL BOUNDARY
- 860 APPROXIMATE SUBBASE GRADE CONTOUR

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY PROFESSIONAL ENGINEERING CONSULTANTS IN JUNE 2016. CONTOURS WERE SUBSEQUENTLY MODIFIED BY APTIM TO REFLECT A RIP-RAP AND SOIL STOCKPILE REMOVAL. EXISTING CONTOURS MAY DIFFER FROM SHOWN.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CCR UNIT BOUNDARY IS APPROX. 53.5 ACRES.
4. ALL BOUNDARIES ARE APPROXIMATE.

REV. NO.	DATE	DESCRIPTION

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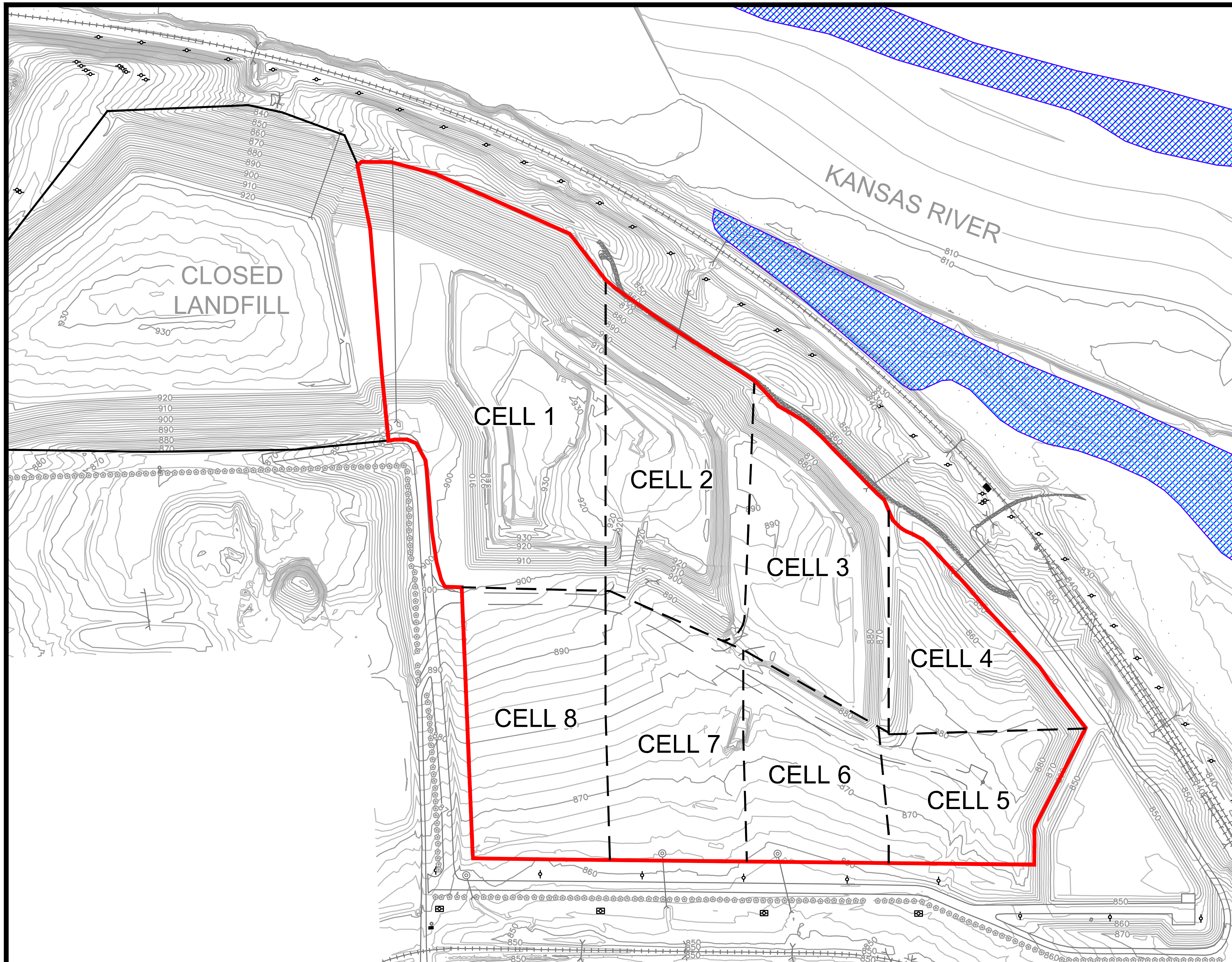
FIGURE 3
LAWRENCE LANDFILL
CELLS 4-8 BASE LINER OVERVIEW

DRAWN BY:	ORC	APPROVED BY:	RDS	PROJ. NO.:	631226111	DATE:	MARCH 2018

T:\AutoCAD\Projects\Westar Energy\Lawrence\Location\Lawrence Fig 3.2.dwg



N

0 300'

GRAPHIC SCALE

LEGEND

- APPROXIMATE CCR UNIT BOUNDARY
- APPROXIMATE LANDFILL CELL BOUNDARY
- APPROXIMATE WETLAND DELINEATION (FRESHWATER FORESTED/SHRUB WETLAND)

NOTES

1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY PROFESSIONAL ENGINEERING CONSULTANTS IN JUNE 2016. CONTOURS WERE SUBSEQUENTLY MODIFIED BY APTIM TO REFLECT A RIP-RAP AND SOIL STOCKPILE REMOVAL. EXISTING CONTOURS MAY DIFFER FROM SHOWN.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. CCR UNIT BOUNDARY IS APPROX. 53.5 ACRES.
4. WETLAND DELINEATIONS AND CLASSIFICATIONS PROVIDED BY THE U.S. FISH AND WILDLIFE SERVICES VIA THE NATIONAL WETLANDS INVENTORY DATABASE.
5. ALL BOUNDARIES ARE APPROXIMATE.

REV. NO.	DATE	DESCRIPTION

Westar Energy

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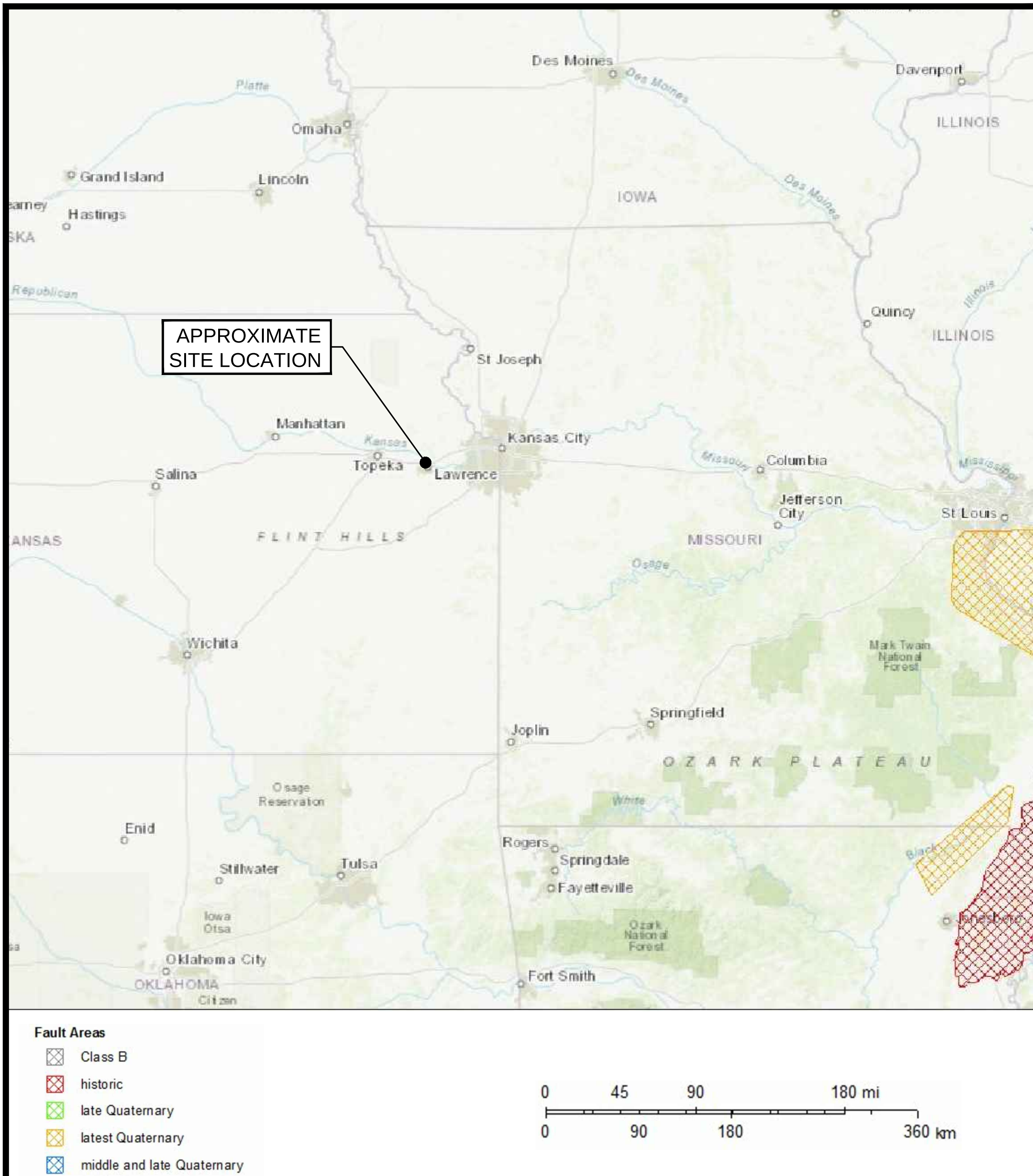
FIGURE 4
LAWRENCE LANDFILL WETLANDS

DRAWN BY: SJL | APPROVED BY: RDS | PROJ. NO.: 631226111 | DATE: MARCH 2018

T:\AutoCAD\Projects\Westar Energy\Lawrence\Location\Lawrence Fig 4.dwg



NOTES

1. Information obtained from the United States Geological Survey Faults and Folds Database.

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LAWRENCE, KANSAS

FIGURE 5
LAWRENCE LANDFILL
MAP OF FAULT AREAS

APPROVED BY: RDS	PROJ. NO.: –	DATE: FEBRUARY 2018

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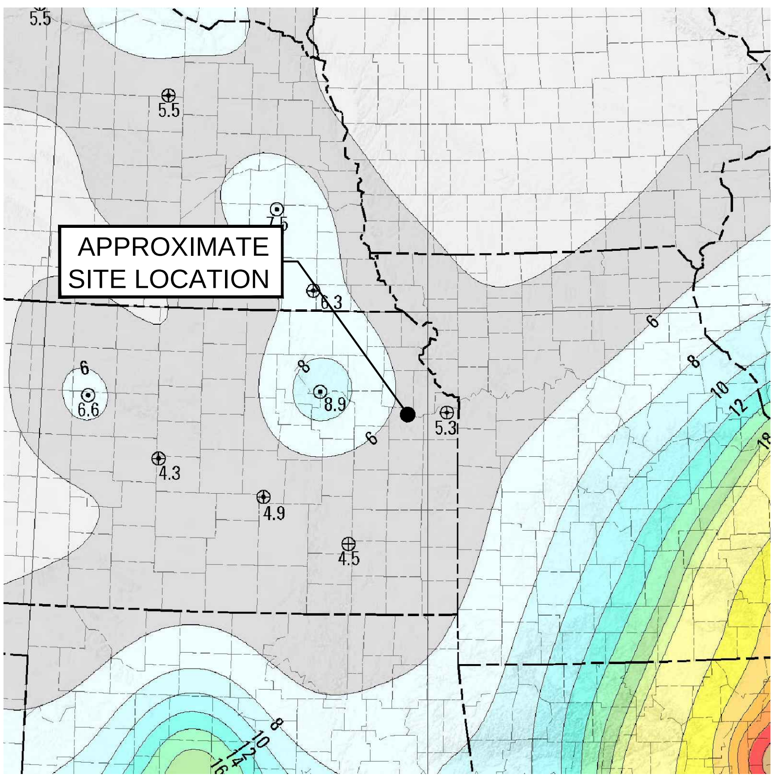
USGS
science for a changing world
Earthquake Hazards Program

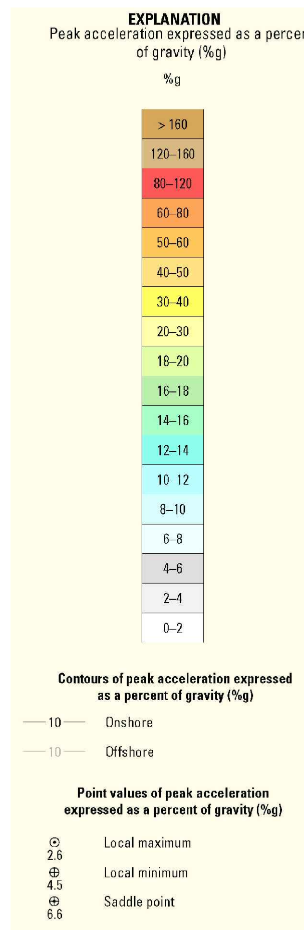
LOCATION 39.003 Lat. -95.258 Long.

The interpolated probabilistic ground motion values, in %g, at the requested point are:

P.E. %	Exp. Time (years)	Ground Motion (g)
2	50	0.0466

U.S. NATIONAL SEISMIC HAZARD MAPS: Peterson, M.D., et al, 2014





Peak Horizontal Acceleration with 2% Probability of Exceedance in 50 Years

NOTES

1. Information obtained from the United States Geological Survey website.

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LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

FIGURE 6
LAWRENCE LANDFILL
MAP OF HORIZONTAL ACCELERATION

APPROVED BY: RDS	PROJ. NO.: –	DATE: FEBRUARY 2018

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APPENDIX A

2005 Phase II Investigation

APTIM

Westar Energy
Lawrence Energy Center Byproduct Landfill
Lawrence, Kansas

Phase II
Hydrogeologic Site Investigation

Volume 1

B&V Project No. 133704

January 2005

BLACK & VEATCH

Westar Energy
Lawrence Energy Center Byproduct Landfill
Lawrence, Kansas

Phase II
Hydrogeologic Site Investigation

B&V Project No. 133704

January 2005

Prepared By: Brian L. Christensen
Geotechnical Engineer
License No. 16013
Expiration Date: April 30, 2006

Prepared By: Edwin W. Meyer III
Geotechnical Engineer
License No. 9766
Expiration Date: April 30, 2005

Reviewed By: Girma Mergia
Ground Water Scientist
Water Resources Engineer
Nebraska License No. E-7169
Expiration Date: December 31, 2006
Pennsylvania License No. PE044147R
Expiration Date: September 30, 2005

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(Figures follow Section 8.0)

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Volume 2

3.0 Previous Investigations

3.1 KDHE/EPA Investigations

KDHE and EPA performed an investigation at the site in 1985, and KDHE performed an additional investigation in 2004. Brief summaries of the investigations and conclusions are presented herein, and the investigation reports are provided in Appendix K.

3.1.1 1985 KDHE and EPA Investigations

During the 1985 KDHE and EPA investigations, three monitoring wells were installed. It is believed that the three wells were plugged; however, no records are available to confirm the plugging of the monitoring wells. Ground water and soil samples were collected during the investigation. Boron was detected in the ground water at an upgradient location with a concentration of 30 micrograms per liter, while downgradient concentrations of boron were 590 and 1,400 micrograms per liter. At a background location the soil had a boron concentration of 10 micrograms per gram, and at a former burn area a soil sample had a boron concentration of 330 micrograms per gram.

One report concludes as follows:

"Based on the short duration of operation of the plant, the low human health hazard associated with boron, the localized nature of aquifer materials, and the absence of other inorganic or organic contaminant, which could have health implications, the former Callery Chemical site does not appear to warrant further investigation by the State."

3.1.2 2004 KDHE Investigation

In the summer of 2004, KDHE performed a supplemental sampling evaluation to confirm that there are not environmental issues at the former Callery industrial facility. The investigation consisted of probing at six locations with a Geoprobe®, drilling with a drill rig at one location, and collecting soil and ground water samples. One temporary well was installed (using the drill rig) for collecting a ground water sample. Following collection of the ground water sample from the temporary well, it was abandoned.

KDHE concludes the following:

"*Based upon the sampling conducted at the site for this SSA* (Supplemental Sampling Assessment), *it appears that a significant release to subsurface soils and ground water from the Callery Chemical site does not remain.*"

3.2 Phase I Hydrogeologic Site Investigation

The Phase I Hydrogeologic Site Investigation Report compiled data from two separate investigations. The first investigation was conducted by Alpha Omega Geotech, Inc. (AOG) in June 1995 at the location of the proposed byproduct landfill. The second investigation was conducted by Black & Veatch in October 1998 at the location of the active coal storage area. Figure 3-1 presents boring locations for these investigations. The Phase I information was used to develop the Phase II program documented in this report.

The AOG investigation consisted of 10 soil borings with soil descriptions and strata depths determined from solid stem auger cutting observations. No discrete soil sampling at depth was conducted for the AOG investigation. Therefore, the boring logs are considered to provide approximations of the subsurface conditions, rather than more precise information regarding the depth of strata obtained using discrete sampling during the Phase II Hydrogeologic Site Investigation. Ground water levels were not indicated on the boring logs. Boring logs for the AOG investigation are presented in Appendix L.

The Black & Veatch investigation consisted of three soil borings with discrete split-spoon sampling and bedrock coring. Ground water levels were indicated on the boring logs. Boring logs for this investigation are presented in Appendix M.

The borings at the proposed byproduct landfill encountered deposits of silt and clay over sand and gravel deposits, which overlie bedrock. The silt and clay deposits range in thickness from approximately 15 to 35 feet within the area of the proposed byproduct landfill. Of the ten borings at the proposed byproduct landfill, eight encountered sand and gravel with an estimated thickness range of 2 to 10 feet. Of these eight borings that encountered sand and gravel, four are thought to have encountered a thin layer of soft clay just below the sand and gravel while the remainder encountered shale bedrock below the sand and gravel. Three of the four borings that encountered the soft clay are closer to the Kansas River than the four borings that did not encounter the soft clay. It is unclear from the boring logs, but it is believed that the soft clay is residual, extremely weathered shale. Two of the borings, B-2 and B-3, which are located adjacent to the flood plain, did not encounter sand and gravel within the depth drilled.

At the three borings in the coal storage area, sand was encountered just beneath the coal. The thickness of the sand was approximately 6 feet. Shale bedrock was encountered beneath the sand. None of the borings encountered a soft clay material between the shale and the sand. These borings are located approximately the same distance away from the Kansas River as the borings that did not encounter the soft clay at the location of the proposed byproduct landfill.

Ground water measurements in the coal storage area indicate the water table ranged from elevation 838 to 844 feet at the completion of the borings. Descriptions of soil cutting moisture on the logs for the borings drilled at the proposed byproduct landfill suggest that the ground water table is approximately located between elevations 838 to 845 feet, similar to the coal storage area.

4.0 Regional and Site-Specific Geologic Setting

4.1 Regional Geologic Setting

The regional geology is characterized by shallow sedimentary rock formations underlying alluvial, glacio-fluvial, and glacio-lacustrine deposits. The abundant glacial type deposits are associated with the Kansan glacier and occur in high to low topographic positions in northern Douglas County. The stratified deposits indicate that near the terminal end of the Kansan glacier the ice mass was melting rapidly and flowing slowly within the Kansas River valley. This glacial melt water produced stratified deposits instead of glacial till deposits by a retreating glacier.

The Burlington Northern and Sante Fe Railway shown on Figure 3-1 appears to be located at the transition between the uplands and the flood plain of the Kansas River, with the uplands located south of the railway. The Kansan Stage deposits occur south of the railway, while Wisconsin Stage alluvium and Newman Terrace deposits occur on the north side of the railway. The Kansan Stage deposits in the uplands are characterized by the Grand Island and Sappa Formations. The Grand Island Formation underlies the Sappa Formation and consists chiefly of coarse gravel and sand. The Sappa Formation consists of silts and clays, and represents deposits formed during the later phase of glacial retreat.

The sedimentary bedrock formations within the State of Kansas consist of interbedded shale, limestone, and sandstone. In the regional area, the Lawrence Shale is overlain by the unconsolidated deposits and is underlain by the Stranger Formation. The Lawrence Shale consists of one member of sandstone, one member of limestone, and two members of shale. The Stranger Formation is divided into one member of sandstone, two members of limestone, and two members of shale. The thickness of the Lawrence Shale increases with increasing distance away from the Kansas River. Approximately 2 miles south of the Kansas River, which runs northwest to southeast, the Lawrence Shale is approximately 300 feet thick. The Lawrence Shale decreases in thickness to the Stranger Formation approximately 1/8 of a mile south of the Kansas River. The Stranger Formation underlies the unconsolidated deposits north of the Kansas River.

4.2 Site-Specific Geologic Setting

The continuous sampling used during the Phase II Hydrogeologic Site Investigation and the discrete sampling used during the supplemental geotechnical investigation are considered more reliable at identifying the depth of geologic strata than the technique of sampling auger cuttings used during the AOG investigation at the proposed landfill site. Therefore, the site-specific geology presented in this report is primarily characterized using the Phase II Hydrogeologic Site Investigation and the supplemental geotechnical investigation borings, with the AOG Phase I investigation borings used for reference only. Cross sections developed using the Phase II Hydrogeologic Site Investigation and the supplemental geotechnical investigation borings are provided on Figures 4-1, 4-2, 4-3, and 4-4. The plan locations of the geologic cross sections are shown on Figure 2-1.

The proposed byproduct landfill site is located in the uplands south of the Burlington Northern and Sante Fe Railway. Characteristic of the Kansan Stage, the borings at the proposed byproduct landfill encountered silt and clay deposits over sand and gravel deposits, which overlie bedrock. The silt and clay deposits consist of clay, sandy clay, silty clay, clayey silt, and sandy silt, with a consistency that ranges from soft to very stiff. The silt and clay deposits range in thickness from 7 feet at MW-23 to 55 feet at P-20 within the area of the proposed byproduct landfill. The silt and clay deposit tends to be thinnest closer to the river, except at B-40 which is further from the river, but only has an 8 foot thickness of clay. The greatest silt and clay deposit thickness occurs at P-20, which is close to the highest elevation investigated.

Throughout most of the site, underlying the silt and clay deposits is a granular deposit that consists of sand, gravelly sand, and clayey sand with a thickness range of 5 feet at MW-24 to 28 feet at P-20 and B-37. This deposit is referred to as sand and gravel herein, based on the regional discussion. Black & Veatch borings B-25 and B-35, and Phase I borings B-2 and B-3 did not encounter sand and gravel above bedrock. These borings are located adjacent to the flood plain. Boring B-33, which is located between Phase I borings B-2 and B-3 did encounter the sand and gravel deposit. Cross section C-C' on Figure 4-3 is cut to show the stratigraphy along the north/east curved portion of the site. The sand and gravel deposit consists mostly of fine to coarse grained sand with occasional layers of gravelly sand and clayey sand. The consistence of the sand and gravel deposit ranges from very loose to very dense.

Borings MW-23, MW-24, B-30, B-31, B-33, B-34, and B-44 encountered a lower cohesive layer below the sand and gravel deposit and immediately above bedrock. At B-35 the consistence of the lowest cohesive layer encountered indicates that it is part of the lower cohesive unit. All these boring locations, except MW-24, are located near the north/east curved portion of the landfill site. The lower cohesive unit consists of sandy clay, silty clay, and clay, with a consistence of soft to hard. The lower cohesive unit ranges in thickness from 0.5 feet at MW-24 to 6.5 feet at B-30 and B-34, and may be residual, weathered shale.

At boring B-31, a 12.5 foot thick layer of clayey gravel is present below the sand and gravel deposit and above the bedrock. The clayey gravel is highly weathered bedrock, with a consistency range of very loose to dense.

All of the borings, except B-38 and B-42, were either terminated after penetrating a short distance into bedrock or were terminated based on drilling refusal on top of the bedrock. At borings P-20, P-21, and MW-23 the bedrock could not be penetrated. At boring P-20 the bedrock was identified as limestone based on limestone cuttings recovered from the tip of the auger and the occurrence of auger refusal. At P-21 and MW-23 the bedrock was not positively identified; however, based on the grinding of the augers, it is possible that the bedrock at these locations was also limestone. Borings MW-22, MW-24, B-25, B-32, B-33, B-34, B-35, B-40, B-41, and B-44 were terminated in shale bedrock, as indicated by shale identified in the last sample collected. B-39 was also terminated in shale based on auger refusal without the grinding associated with the limestone bedrock.

At borings B-30, B-31, B-36, B-37, and B-43 bedrock was indicated by sampler and/or drilling refusal; however, the bedrock type could not be identified. No trend in the distribution of bedrock type was identified.

5.0 Regional and Site-Specific Hydrogeologic Setting

5.1 Regional Hydrogeologic Setting

The regional hydrogeologic setting is characterized by unconsolidated and consolidated bedrock aquifers. The unconsolidated aquifers are present in the Wisconsian Stage alluvium, Newman Terrace deposits, and Kansas Stage deposits. The consolidated bedrock aquifers consist chiefly of sedimentary limestone, shale, and sandstone formations, which have a regional dip averaging about 20 feet per mile to the northwest.

The Wisconsian Stage alluvium and Newman Terrace deposits within the Kansas River valley, north of the proposed byproduct landfill, generally produce large quantities (500 to 1,000 gpm) of ground water. Logs of wells indicate that the alluvium and terrace deposits have a minimum thickness of about 45 feet in much of the river valley and as much as 90 feet along the Kansas River. The saturated water bearing material thickness ranges from about 25 feet to 65 feet.

Unlike the river valley deposits, the Kansan deposits have a wide range of thickness, extent, and character and their ability to store and transmit ground water differs greatly from one locality to another. The Kansan outwash of fluvial deposits may be permeable and transmit ground water readily, while the clayey deposits generally supply little or no ground water. Along the Kansas River between Lawrence and Lakeview, small amounts of ground water can be yielded by a very thin saturated zone of sand and gravel at the base of the Grand Island Formation. Small amounts of ground water can also be yielded from perched water bodies in the Sappa Formation.

In other areas along the Kansas River, the entire thickness of the Kansan Stage deposits can be penetrated without yielding ground water. In this instance, ground water is obtained from the sandstone of the Stranger Formation, which underlies much of the regional area. Ground water is known to occur in consolidated rocks locally to a depth of about 500 feet. The limestone and shale formations in their unweathered state generally will not yield much water. At or near the surface, weathering processes tend to increase or enlarge the open spaces within the rocks, so that locally the rock may yield small quantities of water.

Recharge of the aquifers is primarily from local precipitation and for shallow upland areas local precipitation is the only source of recharge. Lesser amounts of recharge are contributed elsewhere by influent seepage from rivers, streams, and ponds and by subsurface inflow from adjacent areas. Recharge is seasonal in Douglas County. Generally the ground water levels are lowered by natural drainage into streams during the winter and then raised due to spring precipitation and low transpiration and evaporation demands. The amount of recharge is estimated to be about 10 percent of the annual precipitation.

7.0 Conclusions and Recommendations

For the conceptual plan layout of the proposed byproduct landfill shown on Figure 1-3, the Phase I and Phase II Hydrogeologic Site Investigations and the supplemental geotechnical investigation have provided a reasonable estimate of the geology and hydrogeology for the proposed site, and no additional investigation to further define the hydrogeology is recommended at this time. The investigation results indicate that the site investigated is suitable for development of the proposed byproduct landfill for the following reasons:

- The presence of the sand and gravel deposit with a consistent ground water flow should allow a release from the landfill to readily reach a monitoring point where it will be quickly detected, rather than having a release occur over a long period of time that could go undetected.
- No unusual geologic features, such as fault zones, buried stream deposits, or cross cutting structures, were identified that will affect the ability to detect a release from the landfill.
- The thick mantle of natural clay overlying the sand and gravel deposit will provide good construction material and if necessary, some natural clay could be left in place to act as a buffer between the bottom of the landfill and the top of the sand and gravel deposit.

KDHE, Bureau of Waste Management Policy 02-02 related to Separation from and Monitoring of Groundwater at Solid Waste Landfills signed March 6, 2002 states the following:

"New solid waste disposal units must have a minimum vertical separation of 5 feet from the lowest point of a solid waste disposal area (e.g., bottom of the base of the sump) to the highest predicted ground water elevation in the uppermost aquifer underlying the disposal area."

Even though the exact elevation of the bottom of the landfill will not be known until detailed design of the landfill is completed, the lowest bottom elevation of the landfill can be estimated using the ground water elevations provided in this report. The highest ground water elevation measured is 842.21 feet (neglecting the June 9, 2004 sampling event), which was measured during the March 11, 2004 quarterly sampling event. To provide a five foot separation between the bottom of the landfill and the ground water, the bottom of the low point of the landfill should be located above the elevation of 847.2 feet.

The Federal Emergency Management Agency (FEMA), Flood Insurance Rate Maps indicate the 100 year flood level for the Kansas River (Zone AE) adjacent to the proposed landfill site is 834 feet. A copy of portions of FEMA maps for the landfill site are shown on Figure 7-1 with the conceptual landfill layout superimposed on the maps. Using the high ground water elevation measured on March 10, 2004 (842.21 feet) to establish the lowest landfill bottom elevation results in the bottom of the landfill located approximately 13.2 feet above the 100 year flood level. The floodway is provided on the FEMA maps on Figure 7-1. The landfill configuration superimposed on the FEMA maps is outside of the floodway.

Conceptually, the top of the proposed landfill will be at approximately elevation 990 to 1,000 feet, which is about 60 to 70 feet above the adjacent closed landfill, which extends up to approximately elevation 930 feet. A plan view of the landfill closed to elevation 992 to 1,000 feet is shown on Figure 7-2. Cross section cut through the landfill are shown on Figure 7-3. The base of the landfill in the cross sections is set at the lowest elevation possible based on the highest ground water level of 842.21 feet measured in MW-24 on March 10, 2004. For reference the high ground water level is shown on the cross sections.

Figure 2-1 provides conceptual monitoring well locations for long term monitoring of ground water quality at the landfill. Existing monitoring well MW-24 is located upgradient of the landfill and will be used for long term background monitoring. The remainder of the monitoring wells are located to provide a uniform distribution of monitoring points downgradient of the landfill at the point of compliance.

8.0 References

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